

The Journal of Raptor Research

Volume 38 Number 2 June 2004



Published by
The Raptor Research Foundation, Inc.

THE RAPTOR RESEARCH FOUNDATION, INC.
(FOUNDED 1966)

<http://biology.boisestate.edu/raptor/>

OFFICERS

PRESIDENT: BRIAN A. MILLSAP
VICE-PRESIDENT: DAVID M. BIRD

SECRETARY: JUDITH HENCKEL
TREASURER: JIM FITZPATRICK

BOARD OF DIRECTORS

NORTH AMERICAN DIRECTOR #1:
JEFF SMITH

NORTH AMERICAN DIRECTOR #2:
GARY SANTOLO

NORTH AMERICAN DIRECTOR #3:
TED SWEM

INTERNATIONAL DIRECTOR #1:
BEATRIZ ARROYO

INTERNATIONAL DIRECTOR #2:
RUTH TINGAY

INTERNATIONAL DIRECTOR #3:
STEVE REDPATH

DIRECTOR AT LARGE #1: JEMIMA PARRY-JONES

DIRECTOR AT LARGE #2: EDUARDO INIGO-ELIAS

DIRECTOR AT LARGE #3: MICHAEL W. COLLOPY

DIRECTOR AT LARGE #4: CAROL MCINTYRE

DIRECTOR AT LARGE #5: JOHN A. SMALLWOOD

DIRECTOR AT LARGE #6: DANIEL E. VARLAND

EDITORIAL STAFF

EDITOR: JAMES C. BEDNARZ, Department of Biological Sciences, P.O. Box 599, Arkansas State University, State University, AR 72467 U.S.A.

ASSOCIATE EDITORS

JAMES R. BELTHOFF
CLINT W. BOAL
MICHAEL I. GOLDSTEIN
JOAN L. MORRISON

JUAN JOSÉ NEGRO
MARCO RESTANI
FABRIZIO SERGIO
IAN G. WARKENTIN

BOOK REVIEW EDITOR: JEFFREY S. MARKS, Montana Cooperative Research Unit, University of Montana, Missoula, MT 59812 U.S.A.

SPANISH EDITOR: CÉSAR MÁRQUEZ REYES, Instituto Humboldt, Colombia, AA. 094766, Bogotá 8, Colombia

EDITORIAL ASSISTANTS: JENNIFER L. NORRIS, JAIMIE VARNER, JOAN CLARK

The Journal of Raptor Research is distributed quarterly to all current members. Original manuscripts dealing with the biology and conservation of diurnal and nocturnal birds of prey are welcomed from throughout the world, but must be written in English. Submissions can be in the form of research articles, short communications, letters to the editor, and book reviews. Contributors should submit a typewritten original and three copies to the Editor. All submissions must be typewritten and double-spaced on one side of 216 × 278 mm (8½ × 11 in.) or standard international, white, bond paper, with 25 mm (1 in.) margins. The cover page should contain a title, the author's full name(s) and address(es). Name and address should be centered on the cover page. If the current address is different, indicate this via a footnote. A short version of the title, not exceeding 35 characters, should be provided for a running head. An abstract of about 250 words should accompany all research articles on a separate page.

Tables, one to a page, should be double-spaced throughout and be assigned consecutive Arabic numerals. Collect all figure legends on a separate page. Each illustration should be centered on a single page and be no smaller than final size and no larger than twice final size. The name of the author(s) and figure number, assigned consecutively using Arabic numerals, should be pencilled on the back of each figure.

Names for birds should follow the A.O.U. Checklist of North American Birds (7th ed., 1998) or another authoritative source for other regions. Subspecific identification should be cited only when pertinent to the material presented. Metric units should be used for all measurements. Use the 24-hour clock (e.g., 0830 H and 2030 H) and "continental" dating (e.g., 1 January 1999).

Refer to a recent issue of the journal for details in format. Explicit instructions and publication policy are outlined in "Information for contributors," *J. Raptor Res.*, Vol. 37(4), and are available from the editor. Submit manuscripts to J. Bednarz at the address listed above.

COVER: Northern Aplomado Falcon (*Falco femoralis septentrionalis*). Graphite and color pencil drawing by Craig Farquhar (farquhar@grandecom.net).

CONTENTS

APLOMADO FALCON ABUNDANCE AND DISTRIBUTION IN THE NORTHERN CHIHUAHUAN DESERT OF MEXICO. Kendal E. Young, Bruce C. Thompson, Alberto Lafón Terrazas, Angel B. Montoya, and Raul Valdez	107
BLOOD-LEAD AND ALAD ACTIVITY LEVELS OF COOPER'S HAWKS (<i>ACCIPITER COOPERII</i>) MIGRATING THROUGH THE SOUTHERN ROCKY MOUNTAINS. Tobias J. McBride, Jeff P. Smith, Howard P. Gross, and Michael J. Hooper	118
AN ASSESSMENT OF CAGE FLIGHT AS AN EXERCISE METHOD FOR RAPTORS. Dana M. Greene, Mathias Engelmann, and Todd R. Steck	125
MODELING HABITAT USE AND DISTRIBUTION OF HEN HARRIERS (<i>CIRCUS CYANEUS</i>) AND MONTAGU'S HARRIER (<i>CIRCUS PYGARGUS</i>) IN A MOUNTAINOUS AREA IN GALICIA, NORTHWESTERN SPAIN. Luis Tapia, Jesús Domínguez, and Luis Rodríguez	133
CURRENT STATUS OF THE OSPREY IN THE CAPE VERDE ISLANDS. Luís Palma, João Ferreira, Rogério Cangarato, and Pedro Vaz Pinto	141
SHORT COMMUNICATIONS	
DEVELOPMENT OF HUNTING BEHAVIOR IN HACKED APLOMADO FALCONS. Jessi L. Brown, William R. Heinrich, J. Peter Jenny, and Brian D. Mutch	148
SUMMER ROADSIDE RAPTOR SURVEYS IN THE WESTERN PAMPAS OF ARGENTINA. Michael I. Goldstein and Toby J. Hibbitts	152
PEREGRINE FALCONS NESTING ON LAKE BLUFFS ON THE ARCTIC COASTAL PLAIN OF NORTHERN ALASKA. Robert J. Ritchie, Ann M. Wildman, and Clayton M. White	158
UNUSUAL NESTING OF THE LESSER KESTREL (<i>FALCO NAUMANNI</i>) IN THESSALY, GREECE. Christos Vlachos, Dimitris Bakaloudis, and Evangelos Chatzinikos	161
FAT STORES OF MIGRANT SHARP-SHINNED AND COOPER'S HAWKS IN NEW MEXICO. John P. DeLong and Stephen W. Hoffman	163
SPANISH RINGING AND RECOVERY RECORDS OF BOOTED EAGLE (<i>HIERAATUS PENNATUS</i>). IGNACIO S. GARCÍA DIOS.....	168
DIET SHIFT OF BARN OWLS (<i>TYTO ALBA</i>) AFTER NATURAL FIRES IN PATAGONIA, ARGENTINA. Mercedes Sahores and Ana Trejo	174
TROPHIC RELATIONSHIPS BETWEEN WHITE-TAILED KITES (<i>ELANUS LEUCURUS</i>) AND BARN OWLS (<i>TYTO ALBA</i>) IN SOUTHERN BUENOS AIRES PROVINCE, ARGENTINA. Lucas M. Leveau, Carlos M. Leveau, and Ulyses F.J. Pardiñas	178
RELATIVE ABUNDANCE AND DIVERSITY OF WINTER RAPTORS IN SPOKANE COUNTY, EASTERN WASHINGTON. Howard L. Ferguson	181
NESTING OF THE WHITE-THROATED HAWK (<i>BUTEO ALBIGULA</i>) IN DECIDUOUS FORESTS OF CENTRAL CHILE. Eduardo F. Pavez, Christian González, Benito A. González, Cristián Saucedo, Sergio Alvarado, Juan P. Gabella, and Alejandra Arnello	186
LETTERS	
OBSERVATION OF THE CHIMANGO CARACARA (<i>MILVAGO CHIMANGO</i>) FEEDING ON COMMON LESSER TOADS (<i>BUFO FERNANDEZAE</i>). Leandro Alcalde and Sergio D. Rosset	190
CONSUMPTION OF A RINGED KINGFISHER (<i>MEGACERYLE TORQUATA</i>) BY A WHITE-TAILED HAWK (<i>BUTEO ALBICAUDATUS</i>) IN SOUTHEASTERN BRAZIL. José Carlos Motta-Junior and Marco Antonio Monteiro Granzinolli	191
GOLDEN EAGLE (<i>AQUILA CHRYSAETOS</i>) PREDATION ATTEMPTS ON MERRIAM'S TURKEYS (<i>MELEAGRIS GALLPAVO MERRIAMI</i>) IN THE SOUTHERN BLACK HILLS, SOUTH DAKOTA. Chad P. Lehman and Dan J. Thompson	192
A RECORD OF THE ORNATE HAWK-EAGLE (<i>SPIZAETUS ORNATUS</i>) IN NAYARIT, MEXICO. Carlos A. López González, Eduardo Ponce Guevara, Karla Pelz Serrano, Hugo Luna Soria, and Rodrigo Sierra Corona	193

The Raptor Research Foundation, Inc. gratefully acknowledges funds and logistical support provided by Arkansas State University to assist in the publication of the journal.

THE JOURNAL OF RAPTOR RESEARCH

A QUARTERLY PUBLICATION OF THE RAPTOR RESEARCH FOUNDATION, INC.

VOL. 38

JUNE 2004

No. 2

J. Raptor Res. 38(2):107–117

© 2004 The Raptor Research Foundation, Inc.

APLOMADO FALCON ABUNDANCE AND DISTRIBUTION IN THE NORTHERN CHIHUAHUAN DESERT OF MEXICO

KENDAL E. YOUNG¹ AND BRUCE C. THOMPSON²

*New Mexico Cooperative Fish and Wildlife Research Unit and Fishery and Wildlife Sciences Department, Box 30003,
MSC 4901, New Mexico State University,
Las Cruces, NM 88003 U.S.A.*

ALBERTO LAFÓN TERRAZAS

Facultad de Zootecnia, Universidad Autónoma de Chihuahua, Chihuahua, Mexico

ANGEL B. MONTOYA

The Peregrine Fund, Boise, ID 83709 U.S.A.

RAUL VALDEZ

*Fishery and Wildlife Sciences Department, Box 30003, MSC 4901, New Mexico State University,
Las Cruces, NM 88003 U.S.A.*

ABSTRACT.—The northern Aplomado Falcon (*Falco femoralis septentrionalis*) historically occupied coastal prairies, savannas, and desert grasslands from southern Mexico north to southern and southwestern Texas, southern New Mexico, and southeastern Arizona. Current resident Aplomado Falcon populations are primarily in Mexico, with isolated populations in southern Texas and from northern Chihuahua to southern New Mexico. We conducted surveys in semidesert grasslands/savannas and associated habitats in northern Chihuahua to locate Aplomado Falcons and to better delineate their distribution and abundance in the northern Chihuahuan Desert during 1998–99. Data were collected by surveying large tracts, transects in nonrandomly selected grasslands, and from a falcon monitoring study. Based on all survey effort, the minimum known population of adult Aplomado Falcons in the study area in northern Chihuahua was 79 individuals. Aplomado Falcons were primarily associated with grassland communities. Most falcon nests (88%) were found in grassland communities with soaptree yucca (*Yucca elata*) or Torrey yucca (*Y. torreyi*). Aplomado Falcons were found fairly clustered in the north-central to north-eastern part of the study area. We found falcons nesting ca. 50 km west of the Texas border (ca. 120 km south of El Paso) in northern Chihuahua. Because Aplomado Falcons are associated with grassland communities, continued degradation of Chihuahuan Desert semidesert grasslands will continue to influence their distribution.

KEY WORDS: *Aplomado Falcon; Falco femoralis; Chihuahuan Desert; Chihuahua, Mexico; distribution.*

ABUNDANCIA Y DISTRIBUCION DEL HALCÓN PERDICERO EN EL DESIERTO NORTEÑO DE CHIHUAHUA EN MEXICO

RESUMEN.—El Halcón perdicero del norte (*Falco femoralis septentrionalis*) históricamente ha ocupado praderas costeras, sabanas, y pastizales desérticos desde México meridional al norte, hasta el sur y sur occidente de Texas, el sur de Nuevo México y el sur oriente de Arizona. Las poblaciones residentes actuales del halcón perdicero se encuentran principalmente en México, con poblaciones aisladas en el

¹ E-mail address: kyoung@nmsu.edu

² Present address: New Mexico Department of Game and Fish, P.O. Box 25112, Santa Fe, NM 87504 U.S.A.

sur de Texas y desde el Chihuahua del norte hasta el sur de Nuevo México. Conducimos estudios en pastizales/sabanas semidesérticas y hábitats asociados en el Chihuahua del norte para localizar Halcones perdiceros y para hacer un mejor bosquejo de su distribución y abundancia en el Desierto Norteño de Chihuahua durante 1998–99. Los datos fueron colectados estudiando distancias largas por medio de transeptos en pastizales seleccionados (no al azar) y a partir de un estudio de monitoreo de halcones. Con base en todo el esfuerzo de estudio, la población mínima conocida de halcones perdiceros adultos en el área de estudio en el norte de Chihuahua fue de 79 individuos. Los halcones perdiceros estuvieron asociados principalmente con comunidades de pastizales. La mayoría de los nidos de halcón (88%) fueron encontrados en comunidades de pastizales con árboles de yucca (*Yucca elata*) o yucca Torrey (*Y. torreyi*). Los halcones perdiceros se encontraron ligeramente concentrados en la parte norcentral a nororiental de la zona de estudio. Encontramos halcones anidando aproximadamente 50 km al occidente de la frontera de Texas (ca. 120 km al sur de El Paso) en el Chihuahua del norte. Debido a que los halcones perdiceros están asociados con comunidades de pastizales, la continua degradación de los pastizales semidesérticos del Desierto de Chihuahua continuará influenciando su distribución.

[Traducción de César Márquez]

The northern Aplomado Falcon (*Falco femoralis septentrionalis*) occupied coastal prairies, savannas, and desert grasslands historically from southern Mexico north to southern and southwestern Texas, southern New Mexico, and southeastern Arizona (Oberholser 1974, American Ornithologists' Union 1998, Keddy-Hector 2000). In Mexico, Aplomado Falcons historically occurred along the east coast from Tamaulipas to Yucatán, and along the west coast in lowlands from Sinaloa and Nayarit to Oaxaca (Lawrence 1874, Cade et al. 1991, Keddy-Hector 2000; Fig. 1). The U.S. Fish and Wildlife Service (1990) and Howell and Webb (1995) suggested that Aplomado Falcons occurred throughout the northern Mexican Plateau. However, the lack of documented occurrences leaves the falcon's historical distribution in the Chihuahuan Desert and elsewhere in interior northern Mexico unclear. Aplomado Falcon reports in Durango are limited to one falcon sighted in 1950 at high elevation in a pine forest west of Durango City (Webster and Orr 1952). There were no documented reports of Aplomado Falcons in Sonora pre-1966 (Van Rossem 1945, Russell and Monson 1998). Alden (1969) and Gallucci (1981) reported falcon sightings in Sonora in 1966 and 1979; however, Russell and Monson (1998) claimed these sightings were unsubstantiated. In Chihuahua, historical Aplomado Falcon reports were sparse. Bailey (1928) mentions a falcon was taken in 1892 at the playas of Palomas, Chihuahua, near the New Mexico border. Further, a nest was located in Chihuahua, Mexico, southwest of Antelope Wells, New Mexico by Arnold Bayne in 1952 (Truett 2002).

There was better documentation of early falcon reports in the United States' (U.S.) portion of the Chihuahuan Desert (Williams 1997, Truett 2002,

R. Meyer, C. Perez, and S. Williams III unpubl. data). Early reports in the northern Chihuahuan Desert indicated Aplomado Falcons were found in open plains with sparse woody vegetation (e.g., Bendire 1892, Visher 1910, Bailey 1928, Ligon 1961). Specimen records and documented sightings indicated that falcons were common throughout their range in the U.S. until ca. 1930 (Bent 1938, Hector 1987). Arnold Bayne located the last known historical falcon nest in southern New Mexico in 1952 (Ligon 1961). The last known historical falcon nest in southeastern Arizona was pre-1940s (Phillips et al. 1964, Monson and Phillips 1981).

There were occasional Aplomado Falcon sightings in the Chihuahuan Desert in the 1960s, 1970s, and 1980s; however, these sightings were usually discounted because the species was believed to be extirpated from the Chihuahuan Desert. Williams and Hubbard (1991) considered the origin of an Aplomado Falcon photographed in southern New Mexico in 1991 a mystery, citing falcons in the savannas of Veracruz as the closest known population. The resident population in northern Chihuahua was not discovered until 1992.

Current resident northern Aplomado Falcon populations are primarily in Mexico (Fig. 1). Extant populations exist along the Gulf of Mexico to the Yucatán Peninsula (Howell and Webb 1995, Keddy-Hector 2000). Also, an Aplomado Falcon population exists in the northern Chihuahuan Desert from north-central Chihuahua to southern New Mexico (Montoya et al. 1997, Truett 2002, Williams 2002, Young et al. 2002, R. Meyer, C. Perez, and S. Williams III unpubl. data). Since the 1990s, there have been occasional sightings of Aplomado Falcons in northern Chihuahua, Mexico near the New Mexico border, and near Lagunas

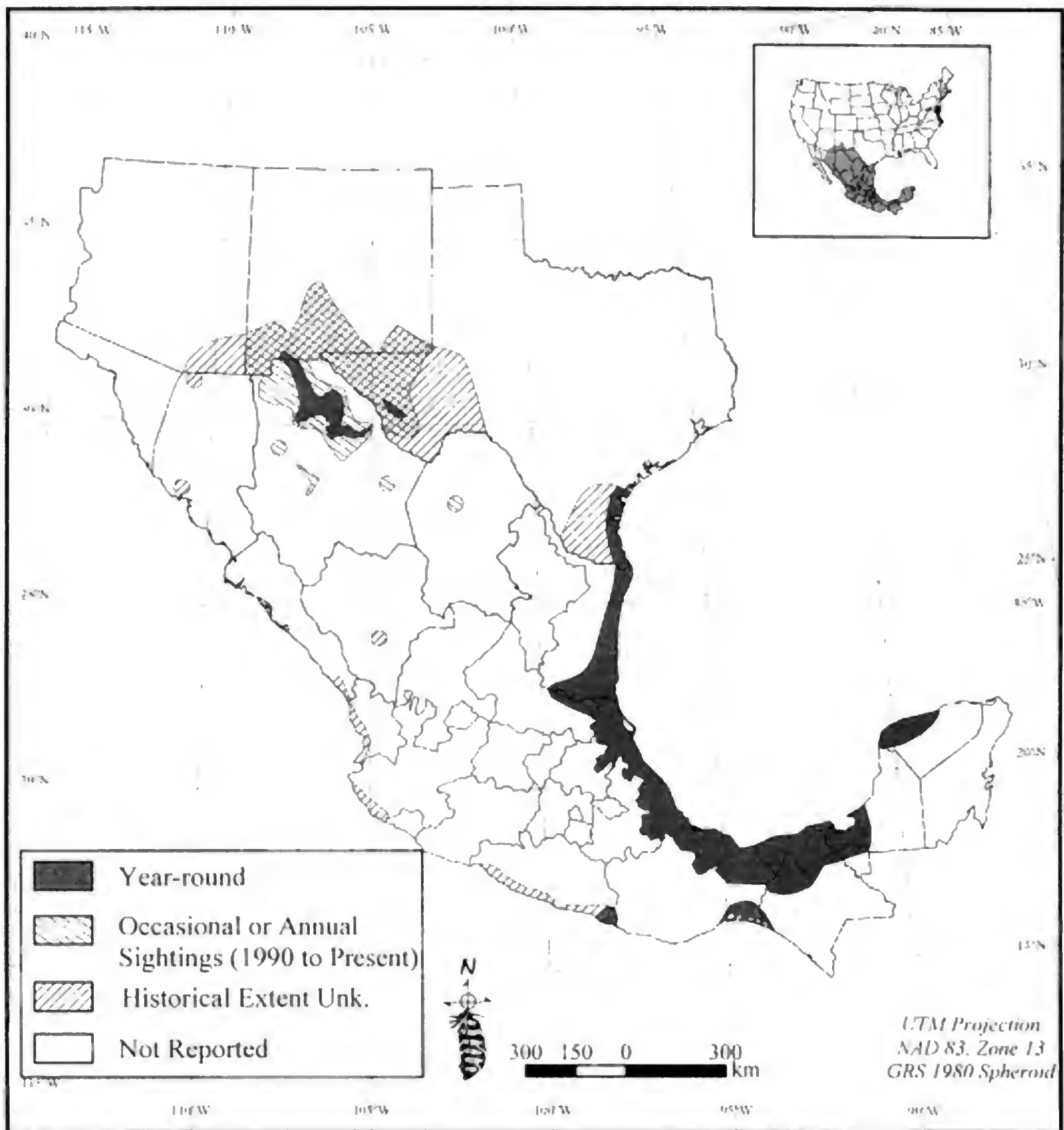


Figure 1. Distribution of northern Aplomado Falcons in the United States and Mexico. Map redrawn from information provided by Lawrence (1874), Webster and Orr (1952), Phillips et al. (1964), Alden (1969), Oberholster (1974), Gallucci (1981), Monson and Phillips (1981), Cade et al. (1991), Howell and Webb (1995), Montoya et al. (1997), Williams (1997), Russell and Monson (1998), Peterson and Zimmer (1998), U.S. Fish and Wildlife Service (1990), Keddy-Hector (2000), Williams (2002), Truett (2002), Meyer (unpubl. data), E. Iñigo-Elias (pers. comm.), and data collected during this study.

Babicora, Mexicanos, and Bustillos, and La Perla (Benítez et al. 1999, Lafon Terrazas unpubl. data). Further, an Aplomado Falcon was sighted in Coahuila in the late 1990s (E. Iñigo-Elias pers. comm.).

In the U.S., there are annual falcon sightings in southern New Mexico and occasional sightings in western Texas (Fig. 1) (Williams 1993, 1994, 1996,

1997, 2000, Peterson and Zimmer 1998, Truett 2002, R. Meyer, C. Perez, and S. Williams III unpubl. data). The first successful nest recorded in New Mexico since 1952 fledged three young in 2002 (Williams 2002, R. Meyer, C. Perez, and S. Williams III unpubl. data). Along the southern Texas coast, a population of Aplomado Falcons was

initiated from reintroduction efforts (Cade et al. 1991). In addition, Aplomado Falcons were released in western Texas in 2002.

The Aplomado Falcon was first considered a candidate for endangered status in 1973 (U.S. Department of the Interior 1973) and was listed as endangered in March 1986 (U.S. Fish and Wildlife Service 1986). At the time of listing, critical habitat was not designated because there were no known nests in the U.S. for at least 25 yr (U.S. Fish and Wildlife Service 1986). The Aplomado Falcon was added to the endangered list due to its loss as a breeding bird in the U.S. and continued threats within its range. Factors that attributed to the falcon's decline were primarily habitat degradation due to woody plant encroachment, and secondarily, egg and specimen collecting, and continued pesticide contamination (DDT) within the range of the falcon (Kiff et al. 1980, U.S. Fish and Wildlife Service 1986, Cade et al. 1991).

The Mexican government listed the northern Aplomado Falcon as endangered in Mexico in May 1994 (DOF-Semarnat 1994, Ceballos and Márquez Valdelamar 2000). However, because information about population-level status of each species was lacking, governmental agencies, scientific institutions, and societies collaborated to review information and produce a new threatened and endangered species list for Mexico. This list was published in March 2002, and the status of the northern Aplomado Falcon was changed from "endangered" to "subject to special protection" (DOF-Semarnat 2002). Subject to special protection status is given to a species or population which could become threatened from factors that negatively affect their viability; thus, there exists a need to promote their recovery and conservation (DOF-Semarnat 2002).

Increases in reliable falcon sightings in the Chihuahuan Desert in the early 1990s prompted additional interest in recovery of the species in New Mexico (Williams 1997, R. Meyer, C. Perez, and S. Williams III unpubl. data). We conducted raptor surveys in semidesert grasslands/savannas and associated habitats in northern Chihuahua, Mexico to locate Aplomado Falcons and to better delineate their distribution and abundance in the northern Chihuahuan Desert. We surveyed a variety of dominant vegetation communities to identify habitat associations. We recorded presence of raptors and ravens (*Corvus* spp.) to investigate the association of Aplomado Falcons with presence of primary nest builders (U.S. Fish and Wildlife Service 1990).

STUDY AREA AND METHODS

Our study area (100 735 km²) consisted of a 160-km belt south of the U.S./Mexico border in Chihuahua, Mexico (Fig. 2). Municipalities in the study area included Ahumada, Aldama, Ascensión, Buenaventura, Camargo, Casas Grandes, Chihuahua, Coyame, Delicias, Galeana, Guadalupe, Janos, Juárez, Julimes, Manuel Benavides, Nuevo Casas Grandes, Ojinaga, Praxedis G. Guerrero, and Zaragoza. Land ownership included private and communal (ejido) land. Annual precipitation is 200–300 mm, the majority ($\geq 80\%$) of which occurs during July–September (COTECOCA 1978). Topography is characterized by disjunct north-southeast-oriented mountain ranges with maximum elevations of ca. 2200 m. Plains, lowlands, and basins are prevalent throughout the study region and are ca. 1200 m above sea level.

Semidesert-basin-grassland communities consist primarily of alkali sacaton (*Sporobolus airoides*) and tobosa (*Pleuraphis mutica*) (COTECOCA 1978, Brown 1994, Young et al. 2002). Lowlands predominantly contain tobosa with honey mesquite (*Prosopis glandulosa*) and soap-tree yucca (*Yucca elata*). Plains are comprised of blue grama (*Bouteloua gracilis*), black grama (*B. eriopoda*), fluff grass (*Dasychloa pulchella*), burrograss (*Scleropogon brevifolius*), alkali sacaton, and sand dropseed (*Sporobolus cryptandrus*) (COTECOCA 1978, Young et al. 2002). Common woody plants in plains consist of honey mesquite, creosote bush (*Larrea tridentata*), acacia (*Acacia* spp.), soap-tree yucca, mariola (*Parthenium incanum*), and tar-bush (*Flourensia cernua*). Sloped areas support sideoats grama (*B. curtispindula*), fluff grass, burrograss, creosote bush, lechuguilla (*Agave lechuguilla*), and sotol (*Dasyliion wheeleri*) (COTECOCA 1978, Brown 1994, Young et al. 2002).

Falcon Surveys. Aplomado Falcon distribution and abundance were described from surveys conducted in large sample tracts and in linear transects in northern Chihuahua during 1998–99. We also included distribution and abundance information from a separate study designed to monitor falcon habitat and productivity in northern Chihuahua (Macias Duarte 2002).

Frequency of occurrence (percent of tracts in which a species occurred) analyses were restricted to raptors and ravens observed during tract surveys. We define a falcon *nest site* as a location where Aplomado Falcons nested, either successfully or unsuccessfully. We refer to a falcon *detection site* as a location where a nest was not found, but either a single or pair of falcons were found one or more times. Reproductive activity was not always determined for detection sites. We use the term *site* to refer to a spatially and temporally independent falcon location (includes both nest and detection sites). As such, falcons located during both years of the study in the same or proximate area were only counted once.

Tract surveys. Survey tracts in northern Chihuahua were selected in two ways: (1) a stratified random sample indicated on the amount of dominant vegetation derived from a 1:250 000 printed vegetation map (INEGI 1982), and (2) a simple random sample of prospective areas identified during an aerial flight of the study area. For samples derived from the vegetation map, ca. amounts of dominant vegetation were estimated by tracing polygon boundaries with a planimeter. A 9 × 9 km grid was placed on the vegetation map, and 60 grids (representing

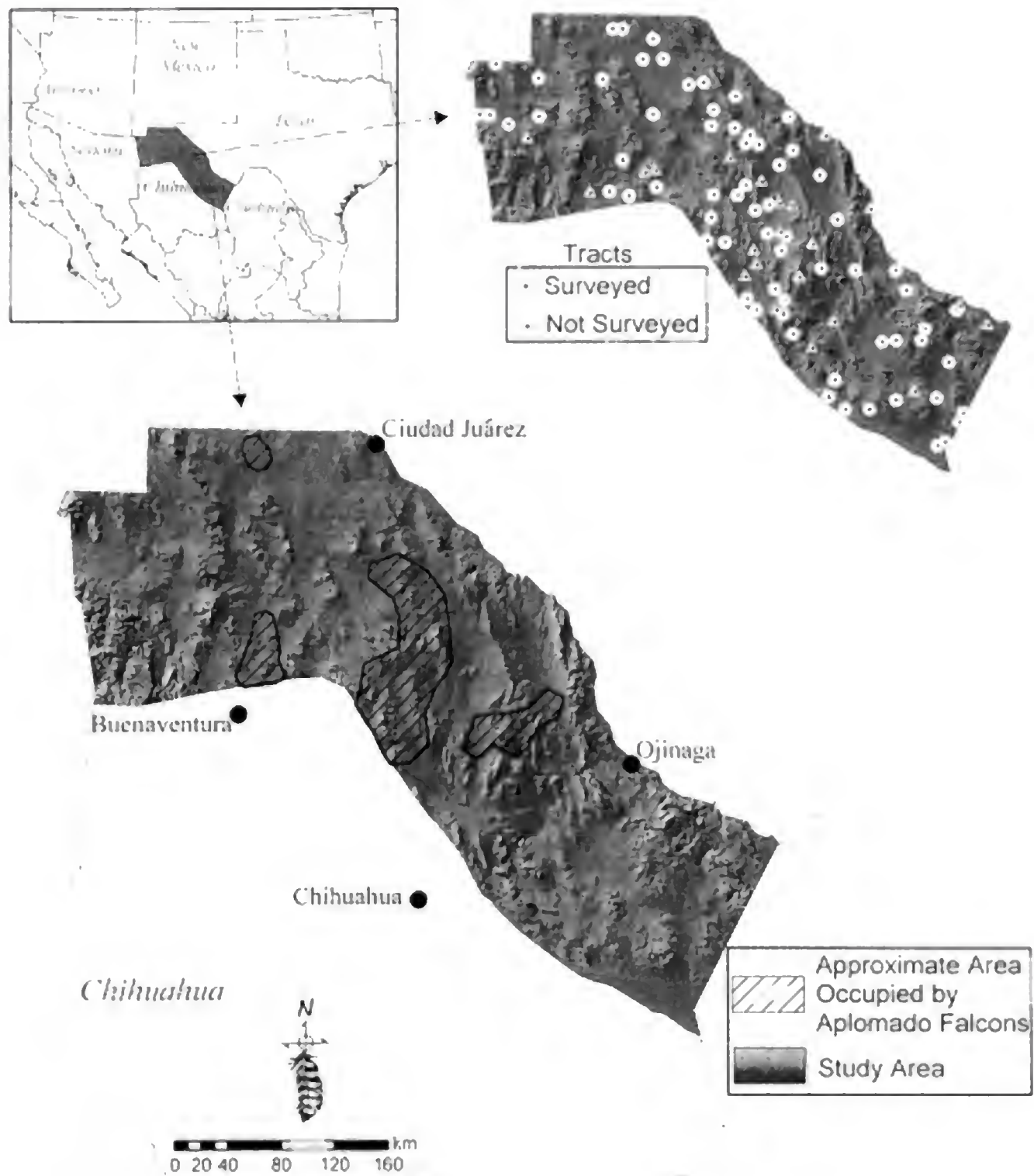


Figure 2. Distribution of tracts surveyed for Aplomado Falcons (upper right corner) and approximate areas occupied by Aplomado Falcons in northern Chihuahua during 1998–99.

survey tracts) were randomly selected in proportion to the percent of vegetation calculated (Table 1). We also flew the entire study area in December 1998 to locate prospective survey areas that represented vegetation communities known to be used by Aplomado Falcons. Prospective areas for sampling were recorded with a Global Positioning System (GPS) receiver for subsequent falcon surveys. We randomly selected 30 of the 58 prospective grassland areas observed for tract placement. After a survey area was located in the field, observers established the largest tract size possible to conduct Aplomado Falcon surveys.

Each tract received a complete, systematic survey by placing point stations at 0.3–1.0 km intervals along roads, depending on vegetation and topography. Observers spent 3–5 min at each point station where they recorded

all raptors and ravens detected using 8× binoculars and a 20× spotting scope. In areas with limited road access, observers walked and established point stations to ensure complete coverage of the tract. Between point stations on roads, observers drove <6 km/hr and recorded all individual raptors observed. Likelihood of double counting individual raptors was minimized by observers recording raptor and raven flight direction and movements during the survey.

Actual surveyed area in tracts was estimated by buffering survey point stations 600-m (ca. maximum observable distance from most point stations) in ArcView 3.2 (Environmental Systems Research Institute, Inc. 2000). As such, tract size and configuration depended on juxtaposition and number of survey stations established.

Transect surveys. Transect surveys were road surveys

Table 1 Dominant vegetation zones derived from a 1:250 000 vegetation map and number of survey tracts randomly placed in each vegetation zone in the northern Chihuahua study area in Mexico.

SPANISH NAME ^a	ENGLISH NAME	AREA ESTIMATED (km ²) ^b	PERCENT OF LAND AREA	NO. OF TRACTS
Pastizal natural	Natural grassland	20 141	20	12
Pastizal holófilo	Grasslands in saline or alkaline conditions	5836	6	4
Matorral rosetófilo	Shrubs—mesquite, cactus, agave, and yucca	10 151	10	6
Matorral desértico micrófilo	Small leaf shrubs primarily in alluvial zones	53 943	52	31
Desierto arenoso	Sand dunes	6042	6	4
Vegetación halófilo	Vegetation in closed basins with high salt content	5772	6	3
Chaparral	Forested area—dense fire resistant trees and shrubs such as oaks and manzanita	805	<1	0
Total		102 690		60 ^c

^a Derived from a printed vegetation map of Chihuahua, Mexico (INEGI 1982).

^b Area estimated with a planimeter.

^c Eleven of these tracts were not examined during field data collection.

(not area based) conducted in nonrandomly selected grasslands and around unconfirmed Aplomado Falcon sightings in northern Chihuahua. Survey methods were similar to tract surveys in that point stations were established at 0.3–1.0 km intervals along roads. However, transect surveys were not designed to survey a given area completely, but provide additional information about selected areas thought to be used by Aplomado Falcons.

Monitoring study. The Aplomado Falcon monitoring study was initiated in 1996 in two areas in northern Chihuahua: one approximately 160 km north of Chihuahua City and the other approximately 160 km northeast of Chihuahua City (Montoya et al. 1997). Falcon territories within the monitoring study area were surveyed for occupancy in 1998 and 1999. A territory was considered occupied when a pair of falcons were observed at or near a nesting structure, and there was no reason to believe the pair was from another territory (Macias Duarte 2002). Each occupied and previously-occupied territory was visited at least twice/mo. In some cases, territories noted as unoccupied may have contained undetected pairs or single birds. Nonnesting pairs were recorded, but not monitored.

Falcon surveys for the monitoring study were conducted from vehicles on roads in areas considered to be potential habitat. Observers stopped ca. every 1.0 km and scanned the terrain for falcons using 10× binoculars and a 15× spotting scope. Surveys were initiated prior to incubation and continued until fledging or failure was confirmed.

Dominant Vegetation Community. Dominant vegetation community was estimated at two different scales. For falcon sites located by the monitoring study and transect surveys, dominant vegetation type was estimated ocularly for an area ca. 500-m around the site center. Conversely, for falcons located during tract surveys, dominant vegetation type was estimated ocularly during falcon surveys and summarized over the entire tract. Surveyors classified dominant vegetation community among three shrub-dominated and four grass-dominated vegetation communities: creosote bush-tarbrush, mesquite-acacia, creosote bush-tarbrush/mesquite-acacia, grass/creosote bush-tarbrush, grass/mesquite-acacia, grass/yucca, or grassland (Buffington and Herbel 1965, Johnson 1977, Rzedowski 1990, Dinerstein et al. 2001). These communities graded from structurally simple types to structurally diverse types varying in density, canopy, and interspersion. This classification was used as a post-stratification description of the tracts and falcon sites.

RESULTS

Survey Effort Among Vegetation Communities. We surveyed 68 tracts (2005 km²) in 1998 and 1999 (Table 2, Fig. 2). Ten tracts were surveyed in both 1998 and 1999, yielding a total of 78 different surveys. Tracts surveyed in both years had either an Aplomado Falcon detection in 1998, or potential Aplomado Falcon habitat. We were unable to survey 22 tracts (11 tracts from the vegetation map sample and 11 prospective areas identified during

Table 2. Total number of tracts and associated area (km²) of dominant vegetation communities surveyed for raptors in northern Chihuahua, Mexico during 1998–99.

DOMINANT VEGETATION COMMUNITY	1998			1999			OVERALL ^a		
	NO. OF TRACTS	AREA (km ²)	% AREA	NO. OF TRACTS	AREA (km ²)	% AREA	NO. OF TRACTS	AREA (km ²)	% AREA
Grassland	2	47	4	6	230	19	7	200	10
Grassland with soaptree/Torrey yucca	2	43	4	4	170	14	5	144	7
Grassland with creosote bush/tarbrush	2	38	3	3	112	9	4	130	6
Grassland with acacia/honey mesquite	5	90	7	11	421	36	13	396	20
Desert shrubland with acacia/honey mesquite and creosote bush/tarbrush	16	492	40	2	60	5	17	536	27
Desert shrubland with acacia/honey mesquite	9	220	18	1	29	2	9	220	11
Desert shrubland with creosote bush/tarbrush	11	312	25	4	160	14	13	379	19
Total	47	1242		31 ^b	1182		68	2005	

^a Total independent tracts surveyed in 1998–99; 10 tracts were surveyed in both yr.

^b Includes 10 tracts surveyed in 1998.

the flight of the study area) due to restricted land access or time constraints (Fig. 2).

During May–October 1998, four field crews spent 308 hr surveying 47 tracts. Tract area averaged 26.4 ± 1.1 km², but ranged from 7.0–41.8 km². In 1998, we surveyed 1242 km² in the tracts and a total of ca. 1300 km² including transect surveys.

During February–October 1999, five field crews surveyed 31 tracts representing 438 hr of survey time. Tract area averaged 38.1 ± 2.9 km², but ranged from 16.4–77.7 km². In 1999, we surveyed 1182 km² in the tracts and a total of ca. 1467 km² including transect surveys. Larger tracts were not feasible to establish and survey because of vegetation heterogeneity, restricted land access, and time constraints.

Tracts surveyed in 1998 were primarily shrub-dominated communities (84%), comprised of creosote bush-tarbrush, mesquite-acacia, or creosote-tarbrush/mesquite-acacia. Conversely, in 1999, tracts surveyed were primarily in grassland communities (75%), represented by grasslands with or without complexes of mesquite-acacia, creosote bush-tarbrush, or yucca (Table 2).

Aplomado Falcon Abundance and Distribution. Aplomado Falcons were detected in 17 (25%) of the 68 tracts surveyed. Tract surveys yielded four nests and 14 detection sites, representing 11 falcon pairs and seven singles, for a total of 29 birds. No additional falcons were found in tracts surveyed in both years. An additional three pairs (one nest and two detection sites) were located during transect surveys. The monitoring study located 13 falcon nests and nine detection sites representing 22 pairs. Based on combined survey effort, the minimum known population of adult Aplomado Falcons identified in the study area during the survey period was 79 individuals (43 independent sites; 18 nest and 25 detection sites). However, given that detection rates for Aplomado Falcons was low (e.g., >40 survey hr per site was needed for each detection), additional falcons probably would be located with additional surveys.

Aplomado Falcons were associated with most vegetation types, but they were detected most often in grass-dominated communities (Table 3). Specifically, 16 (88%) Aplomado Falcon nests and 10 (40%) detection sites were found in grassland communities with soaptree yucca or Torrey yucca (*Y. torreyi*). Of the 79 individuals found in northern Chihuahua, only three single birds were located in

Table 3. Minimum numbers of Aplomado Falcon sites and individuals identified in each dominant vegetation community in northern Chihuahua, Mexico in 1998-99.

DOMINANT VEGETATION COMMUNITY	NO. OF SITES			NO. OF			MINIMUM NO. OF	
	NESTS	DETECTION	PAIRS	SINGLES	SITES	INDIVIDUALS		
Grassland	1	3	3	1	4	7		
Grassland with soaptree/Torrey yucca	16	10	26	—	26	52		
Grassland with creosote bush/tarbush	—	5	3	2	5	8		
Grassland with acacia/honey mesquite	1	4	4	1	5	9		
Desert shrubland with acacia/honey mesquite and creosote bush/tarbush	—	2	—	2	2	2		
Desert shrubland with acacia/honey mesquite	—	1	—	1	1	1		
Desert shrubland with creosote bush/tarbush	—	—	—	—	—	—		
Total	18	25	36	7	43	79		

shrub-dominated communities. No falcon detections occurred in creosote bush/tarbush communities (Table 3).

Aplomado Falcons were fairly concentrated in the north-central to northeastern part of the study area (Fig. 2). This distribution coincides closely with the distribution of extensive grasslands in northern Chihuahua identified from our aerial flight. We found falcons nesting ca. 50 km west of the Texas border (ca. 120 km south of El Paso, TX) in northern Chihuahua. Also, single Aplomado Falcons were detected in the same area ca. 12-18 km south of the New Mexico border near Palomas, Chihuahua, in each survey yr. Reproductive status for these detections was not determined.

Aplomado Falcons rely on nests constructed by other raptors or corvids. Potential nest builders present in northern Chihuahua included ravens (primarily *Corvus cryptoleucus*), Swainson's Hawk (*Buteo swainsoni*), Red-tailed Hawk (*Buteo jamaicensis*), Harris's Hawk (*Parabuteo unicinctus*), and White-tailed Kite (*Elanus leucurus*). Except Harris's Hawk and White-tailed Kite, these nest builders were common in tracts where Aplomado Falcons were detected (>70% frequency; Table 4). Swainson's Hawks, Red-tailed Hawks, and ravens were more commonly detected in tracts with Aplomado Falcons than in tracts without Aplomado Falcons ($\chi^2 = 34.56$, $df = 3$, $P < 0.001$).

DISCUSSION AND CONSERVATION IMPLICATIONS

Aplomado Falcons are fairly conspicuous when foraging or perching on tall substrates. However, locating new falcons required >40 survey hr per site (estimated from tract surveys), and determining nesting status required additional time. As such, methods that require complete surveys of large areas are more likely to detect falcons. We detected falcons in 25% of tracts surveyed, locating 18 falcon sites which were not previously known. Given the short duration of surveys, we feel the tract survey method provided reasonable results.

Before the 1980s, information on Aplomado Falcons in the Chihuahuan Desert was limited to a few incidental and historical accounts. The state of knowledge has developed from the perception that Aplomado Falcons were extirpated from the Chihuahuan Desert, to documenting a population that exists from north-central Chihuahua to southern New Mexico. However, it seems that the falcon population on the Mexican Plateau is geographically isolated from coastal populations (Fig. 1). Additional research is necessary to better define pop-

Table 4. Association of raptor species observed in 17 survey tracts with Aplomado Falcon detections and 51 tracts without Aplomado Falcon detections in northern Chihuahua, Mexico in 1998–99.

	NUMBER OF TRACTS			
	WITH APLOMADO FALCONS ^a		WITHOUT APLOMADO FALCONS	
	NUMBER	PERCENT	NUMBER	PERCENT
Swainson's Hawk	17	100	33	65
Ravens	16	94	49	96
Red-tailed Hawk	12	71	25	49
White-tailed Kite	2	12	1	2
Harris's Hawk	1	6	1	2

^a Detection of Aplomado Falcons was highly associated with tracts where hawks and ravens were detected ($\chi^2 = 34.56$, $df = 3$, $P = <0.001$); White-tailed Kite and Harris's Hawk detections were combined for analyses.

ulation dynamics and connectivity between falcon populations in Mexico.

The U.S. Fish and Wildlife Service (1990) stated that critical information regarding falcon distribution, abundance, and habitat requirements in Mexico was needed to aid in recovery of the species. Our study, as well as studies by Montoya et al. (1997), Truett (2002), and R. Meyer, C. Perez, and S. Williams III (unpubl. data), will aid resource managers in developing recovery strategies for the falcon in the Chihuahuan Desert by providing baseline information on the current distribution of the falcon.

The Chihuahuan Desert is the largest desert (ca. 629 000 km²) in North America (Beck and Gibbens 1999, Dinerstein et al. 2001) and is among the most biologically diverse desert ecoregions worldwide (Ricklefs and Schluter 1993). Most of the Chihuahuan Desert is located in the states of Chihuahua and Coahuila in Mexico, but portions extend into eastern Arizona, southern New Mexico, and western Texas. This vast and unique arid region supports a wide variety of habitats including grasslands, scrublands, shrub communities, and yucca woodlands as well as mixed conifer forests and oak woodlands at higher elevations (Gehlbach 1993). About 14% of Mexico's land area is covered by grasslands of which 90% occur in arid and semi-arid regions (Burquez et al. 1998). Although limited in area, grasslands are vital to certain species and to the biodiversity of the Chihuahuan Desert (Beck and Gibbens 1999).

The Mexican government created the National Commission for the Knowledge and Use of Biodiversity (CONABIO) in 1992 that established a network of regional areas that were important for bio-

diversity conservation. In the Chihuahuan Desert portion of the Aplomado Falcon's range, four priority areas for biodiversity conservation in grassland habitats were identified (Arizmendi and Márquez 1999). CONABIO also established areas that were considered important for the conservation of birds (AICAS) in Mexico. However, within the range of the Aplomado Falcon in the Chihuahuan Desert, there was only one area designated near Janos, Chihuahua. Although there are occasional falcon sightings in this AICAS, there were no AICAS designated in areas of known year-round Aplomado Falcon habitation. Given the falcon's status of "subject to special protection" in Mexico, updated information on Aplomado Falcon distribution may assist in evaluating areas for future AICAS in Chihuahua, Mexico and promote falcon recovery and conservation.

The U.S. Fish and Wildlife Service (1986) implicates habitat degradation due to brush encroachment as the main factor responsible for disappearance of Aplomado Falcons from the U.S. The Chihuahuan Desert has undergone considerable transition in vegetation communities since the mid-1800s, primarily from perennial grassland to shrubland (Buffington and Herbel 1965, Allred 1996, Beck and Gibbens 1999). Over the past century, factors such as climatic changes, diversion of surface water for agricultural purposes, livestock grazing, erosion, introduction of exotic plant and animal species, and increased urban development have profoundly and negatively impacted the natural processes of the Chihuahuan Desert (Lloyd et al. 1998, Beck and Gibbens 1999). Changes in bird assemblages, including raptors, associated with altered vegetation structure and climatic conditions

have been detected and discussed by Raitt and Pimm (1976, 1977) and Lloyd et al. (1998) for Chihuahuan Desert environments. Change in grasslands will naturally affect species that are grassland adapted. The current state of knowledge on Aplomado Falcons indicates that this falcon is likely to be detrimentally affected by alteration and loss of grassland habitat. Further, key raptor or raven species relied upon by Aplomado Falcons to provide nest structures have substantial association with grassland dominated communities (Desmond et al. in press). Grassland conservation is paramount in conserving Aplomado Falcons and other grassland birds in the Chihuahuan Desert.

ACKNOWLEDGMENTS

Research was funded by the Bureau of Land Management, White Sands Missile Range, Fort Bliss Military Reservation, U.S. Fish and Wildlife Service, Sevilleta National Wildlife Refuge, The Peregrine Fund, Border Wildlife Consultants, T & E, Inc., La Tierra Consulting, World Wildlife Fund, and Geo-Marine Inc. Additional financial support was provided by the New Mexico Agricultural Experiment Station. We greatly appreciate the Secretaria de Medio Ambiente Recursos Naturales y Pesca for providing the necessary permits to conduct research in Mexico. We thank A. Alvarez, E. Carreon, E. Carrillo, C. Mendez, R. Meyer, J. Montoya, C. Morales, F. Pinion, R. Rodriguez, C. Sanchez, and E. Zamarron for their assistance in collecting data. S. Lanham, Environmental Flying Services, Tucson Arizona, provided a productive flight over northern Chihuahua. We thank M. Howard, B. Locke, R. Meyer, C. Perez, and S. Williams for helpful critiques of this manuscript. We thank the numerous private landowners in Chihuahua, Mexico with a special thanks to A. Borunda and E. Baeza for providing land access.

LITERATURE CITED

- ALDEN, P. 1969. Finding the birds in Western Mexico; a guide to the States of Sonora, Sinaloa, and Nayarit. Univ. Arizona Press, Tucson, AZ U.S.A.
- ALLRED, K.W. 1996. Vegetative changes in New Mexico rangelands. *N.M. J. Sci.* 36:169–231.
- AMERICAN ORNITHOLOGISTS' UNION. 1998. Checklist of North American birds, 7th Ed. American Ornithologists' Union, Washington, DC U.S.A.
- ARIZMENDI, M.C. AND V.L. MÁRQUEZ. 1999. Áreas de importancia para la conservación de las aves de México. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad, Mexico, D.F. Mexico.
- BAILEY, F.M. 1928. Birds of New Mexico. New Mexico Game and Fish, Sante Fe, NM U.S.A.
- BECK, R.F. AND R.P. GIBBENS. 1999. The Chihuahuan Desert ecosystem. *N.M. J. Sci.* 39:45–85.
- BENDIRE, C.E. 1892. Life histories of North American birds. *U.S. Natl. Mus. Bull.* 1:551–558.
- BENÍTEZ, H., C. ARIZMENDI, AND L. MÁRQUEZ. 1999. Base de Datos de las AICAS. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad, Mexico, D.F. Mexico.
- BENT, A.C. 1938. Life histories of North American birds of prey, part two. *U.S. Natl. Mus. Bull.* 170:96–99.
- BROWN, D.E. (ED.). 1994. Biotic communities: southwestern United States and northwestern Mexico. Univ. Utah Press, Salt Lake City, UT U.S.A.
- BUFFINGTON, L.C. AND C.H. HERBEL. 1965. Vegetational changes on a semiarid desert grassland range from 1858–1963. *Ecol. Monogr.* 35:139–164.
- BURQUEZ, A., A. MARTINEZ-YRZAR, M. MILLER, K. ROJAS, M. DE LOS ANGELES-QUINTANA, AND D. YETMAN. 1998. Mexican grasslands and the changing aridlands of Mexico: an overview and a case study in northwestern Mexico. Pages 21–32 in B. Tellman, D.M. Finch, C. Edminster, and R. Hamre [EDS.], The future of arid grasslands: identifying issues, seeking solutions. Proceedings RMRS-P3, USDA, Forest Service, Rocky Mountain Research Service, Fort Collins, CO U.S.A.
- CADE, T.J., J.P. JENNY, AND B.J. WALTON. 1991. Efforts to restore the northern Aplomado Falcon (*Falco femoralis septentrionalis*) by captive breeding and reintroduction. *Dodo, J. Jersey Wildl. Preserv. Trust* 27:71–81.
- CEBALLOS, G. AND L. MÁRQUEZ VALDELMAR. (EDS.) 2000. Las aves de México en peligro de extinción. Instituto de Ecología, Mexico, D.F. Mexico.
- COTECOCA. 1978. Comisión técnico consultiva para la determinación regional de los coeficientes de agostadero, Chihuahua, Mexico.
- DOF-SEMARNAT. 1994. Norma Oficial Mexicana NOM-059-ECOL-1994, que determina las especies y subespecies de flora y fauna silvestre terrestres y acuáticas en peligro de extinción, amenazadas, raras y las sujetas a protección especial, y que establece especificaciones para su protección. Diario Oficial de la Fed., Primera Sección. Mexico, D.F. Mexico.
- . 2002. Norma Oficial Mexicana NOM-059-ECOL-2001, protección ambiental—especies nativas de México de flora y fauna silvestres—categorías de riesgo y especificaciones para su inclusión, exclusión o cambio—lista de especies en riesgo. Diario Oficial de la Fed., Segunda Sección. Mexico, D.F. Mexico.
- DESMOND, M.J., K.E. YOUNG, B.C. THOMPSON, R. VALDEZ, AND A. LAFÓN TERRAZAS. In press. Habitat associations and conservation of grassland birds in the Chihuahuan Desert Region: two case studies in Chihuahua, Mexico. In J.L.E. Cartron, G. Ceballos, and R.S. Felger [EDS.], Biodiversity, ecosystems, and conservation in northern Mexico. Oxford Univ. Press, New York, NY U.S.A.
- DINERSTEIN, E., D. OLSON, J. ATCHLEY, C. LOUCKS, S. CONTRERAS-BALDERAS, R. ABELL, E. IÑIGO, E. ENKERLIN, C. WILLIAMS, AND G. CASTILLEJA. 2001. Ecoregion-based conservation in the Chihuahuan Desert: a biological assessment. World Wildlife Fund, Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO), The Nature Conservancy, PRONATURA Noreste, and Instituto Tecnológico y de Estudios Superiores de Monterrey, Washington DC U.S.A.
- ENVIRONMENTAL SYSTEMS RESEARCH INSTITUTE, INC. 2000. ArcView GIS (Version 3.2a). Environmental Systems Research Institute, Inc., Redlands, CA U.S.A.
- GALLUCCI, T. 1981. Summer bird records from Sonora, Mexico. *Am. Birds* 35:243–247.

- GEHLBACH, F.R. 1993. Mountain islands and desert seas: a natural history of the U.S.-Mexican borderlands. Texas A&M Univ. Press, College Station, TX U.S.A.
- HECTOR, D.P. 1987. The decline of the Aplomado Falcon in the United States. *Am. Birds* 41:381–389.
- HOWELL, S.N.G. AND S. WEBB. 1995. The birds of Mexico and northern Central America. Oxford Univ. Press, New York, NY U.S.A.
- INEGI. 1982. Mapa de vegetación natural e inducida. Coordinación General de los Servicios Nacionales de Estadística Geografía e Informática. Mexico, D.F. Mexico.
- JOHNSON, M.C. 1977. Brief resume of botanical, including vegetational, features of the Chihuahuan Desert region with special emphasis on their uniqueness. Pages 335–359 in R.H. Wauer and D.H. Riskind [EDS.], Transactions of the symposium on the biological resources of the Chihuahuan Desert region: United States and Mexico. USDI, National Park Service Transactions and Proceedings, Washington, DC U.S.A.
- KEDDY-HECTOR, D.P. 2000. Aplomado Falcon (*Falco femoralis*). In A. Poole and F. Gill [EDS.], The birds of North America, No. 549. The Birds of North America, Inc., Philadelphia, PA U.S.A.
- KIFF, L.F., D.B. PEAKALL, AND D.P. HECTOR. 1980. Eggshell thinning and organochloride residues in bat and Aplomado Falcons in Mexico. *Proc. Int. Ornithol. Congr.* 17:949–952.
- LAWRENCE, G.N. 1874. Birds of western and northwestern Mexico, based upon collections made by Col. A.J. Grayson, Capt. J. Xantus, and Fred. Bischoff. *Mem. Boston Soc. Nat. Hist.* 2:265–319.
- LIGON, J.S. 1961. New Mexico birds and where to find them. Univ. New Mexico Press, Albuquerque, NM U.S.A.
- LLOYD, J., R.W. MANNAN, S. DESTEFANO, AND C. KIRKPATRICK. 1998. The effects of mesquite invasion on a southeastern Arizona grassland bird community. *Wilson Bull.* 110:403–408.
- MACIAS DUARTE, A. 2002. Exito reproductivo, presas potenciales y habitat del Halcon Aplomado (*Falco femoralis septentrionalis*) Todd, en Chihuahua, Mexico. Universidad Autonoma de Chihuahua, Tesis de Maestria, Chihuahua, Mexico.
- MONSON, G. AND A.R. PHILLIPS. 1981. Annotated checklist of the birds of Arizona. The Univ. Arizona Press, Tucson, AZ U.S.A.
- MONTOYA, A.B., P.J. ZWANK, AND M. CARDENAS. 1997. Breeding biology of Aplomado Falcons in desert grasslands of Chihuahua, Mexico. *J. Field Ornithol.* 68:135–143.
- OSBERG, H.C. 1974. The bird life of Texas. Univ. Texas Press, Austin, TX U.S.A.
- PETERSON, J. AND B.R. ZIMMER. 1998. Birds of the Trans-Pecos. Univ. Texas Press, Austin, TX U.S.A.
- PHILLIPS, A., J. MARSHALL, AND G. MONSON. 1964. The birds of Arizona. The Univ. Arizona Press, Tucson, AZ U.S.A.
- RAITT, R.J. AND S.L. PIMM. 1976. Dynamics of bird communities in the Chihuahuan Desert, New Mexico. *Condor* 78:427–442.
- . 1977. Temporal changes in northern Chihuahuan Desert bird communities. Pages 579–590 in R.H. Wauer and D.H. Riskind [EDS.], Transactions of the symposium on the biological resources of the Chihuahuan Desert region: United States and Mexico. U.S.D.I., National Park Service Transactions and Proceedings, Washington, DC U.S.A.
- RICKLEFS, R.E. AND D. SCHLUTER [EDS.]. 1993. Species diversity in ecological communities: historical and geographical perspectives. Univ. Chicago Press, Chicago, IL U.S.A.
- RUSSELL, S.M. AND G. MONSON. 1998. The birds of Sonora. The Univ. Arizona Press, Tucson, AZ U.S.A.
- RZEDOWSKI, J. 1990. Vegetación potencial Atlas Nacional de Mexico: Vol. II Escala 1:4,000,000. Instituto de Geografía, UNAM, Mexico.
- TRUETT, J.C. 2002. Aplomado Falcons and grazing: invoking history to plan restoration. *Southwest. Nat.* 47:379–400.
- U.S. DEPARTMENT OF THE INTERIOR. 1973. Threatened wildlife of the United States. U.S. Bureau of Sport Fisheries and Wildlife Resource Publication 114:1–289.
- U.S. FISH AND WILDLIFE SERVICE. 1986. Final rule: listing of the Aplomado Falcon as endangered. United States Fish and Wildlife Service, Federal Register 51:6686–6690.
- . 1990. Aplomado Falcon recovery plan. U.S. Fish and Wildlife Service, Albuquerque, NM U.S.A.
- VAN ROSSEM, A.J. 1945. A distributional survey of the birds of Sonora, Mexico. Louisiana State Univ. Press, Baton Rouge, LA U.S.A.
- VISHER, S.S. 1910. Birds of Pima County, Arizona. *Auk* 27:279–288.
- WEBSTER, J.D. AND R.T. ORR. 1952. Notes on Mexican birds for the states of Durango and Zacatecas. *Condor* 54:309–313.
- WILLIAMS, S.O. III. 1993. New Mexico. *Am. Birds* 47:130–133.
- . 1994. New Mexico. *Am. Birds* 48:236–238.
- . 1996. New Mexico. *Nat. Audubon Soc. Field Notes* 50:980–983.
- . 1997. Recent occurrences of Aplomado Falcons in New Mexico: is natural recolonization of historic range underway? *N.M. Ornith. Soc. Bull.* 25:39.
- . 2000. New Mexico. *N. Am. Birds* 54:86–89.
- . 2002. New Mexico. *N. Am. Birds* 56:467–470.
- AND J.P. HUBBARD. 1991. New Mexico. *Am. Birds* 45:1146–1148.
- YOUNG, K.E., B.C. THOMPSON, D.M. BROWNING, Q.H. HODGSON, J.L. LANSER, A. LAFON TERRAZAS, W.R. GOULD, AND R. VALDEZ. 2002. Characterizing and predicting suitable Aplomado Falcon habitat for conservation planning in the northern Chihuahuan Desert. New Mexico Cooperative Fish and Wildlife Research Unit, Las Cruces, NM U.S.A.

BLOOD-LEAD AND ALAD ACTIVITY LEVELS OF COOPER'S HAWKS (*ACCIPITER COOPERII*) MIGRATING THROUGH THE SOUTHERN ROCKY MOUNTAINS

TOBIAS J. McBRIDE¹

The Institute of Environmental and Human Health, Environmental Toxicology Department, Texas Tech University, Lubbock, TX 79409 U.S.A.

JEFF P. SMITH AND HOWARD P. GROSS²

HawkWatch International, 1800 South West Temple, Salt Lake City, UT 84115 U.S.A.

MICHAEL J. HOOPER

The Institute of Environmental and Human Health, Environmental Toxicology Department, Texas Tech University, Lubbock, TX 79409 U.S.A.

ABSTRACT.—Predatory or scavenging raptors can be exposed to lead contamination through the ingestion of hunter-injured or killed game species that contain residual lead bullets, pellets, or fragments thereof, or prey contaminated by lead from other anthropogenic sources. We studied the incidence of lead exposure in Cooper's Hawks (*Accipiter cooperii*) by sampling southward and northward migrating populations. Cooper's Hawks have been regularly captured for biological data collection at two long-term monitoring and banding stations in north-central New Mexico. We identified blood-lead concentrations, erythrocyte ALAD activity, and hematocrit levels in fall migrating adults and juveniles ($N = 45$ and 15 , respectively), and spring migrating adults ($N = 38$; no juveniles were captured in spring). Blood-lead concentrations of spring migrating adults ($\bar{x} = 0.063 \pm \text{SE } 0.011 \mu\text{g/g}$) were significantly greater than both fall adults and juveniles ($0.032 \pm 0.003 \mu\text{g/g}$ and $0.028 \pm 0.004 \mu\text{g/g}$, respectively). Blood-lead concentrations did not reach levels sufficient to inhibit erythrocyte ALAD activity or depress hematocrit levels. ALAD activity appeared to be age-dependent, however, as activity in fall juveniles (74.9 ± 2.2 units) was significantly greater than in both fall and spring adults (63.0 ± 2.9 units and 54.0 ± 3.1 units, respectively). Hematocrit values indicated no detectable differences between migration season or age. Our findings suggested that Cooper's Hawks were exposed to higher environmental levels of lead in their winter range than they were in the breeding range, though not at concentrations known to cause detrimental health effects.

KEY WORDS: *Cooper's Hawk; Accipiter cooperii; lead; ALAD; migration; toxicology.*

PLOMO SANGUINEO Y NIVELES DE ACTIVIDAD ALAD EN HALCONES DE COOPER MIGRATORIOS (*ACCIPITER COOPERII*) EN EL SUR DE LAS MONTAÑAS ROCOSAS

RESUMEN.—Las rapaces de predadoras o carroñeras pueden estar expuestas a contaminación con Plomo a través de la ingestión de especies de caza, heridas o matadas, que contienen plomo residual de balas, perdigones, fragmentos de los mismos, o presas contaminadas con plomo a partir de otras fuentes antropogénicas. Estudiamos la potencialidad a la exposición al plomo en los gavilanes de Cooper (*Accipiter cooperii*) tomando muestras de sus poblaciones migratorias hacia el sur y hacia el norte. Los Halcones de Cooper han sido capturados regularmente para coleccionar datos biológicos en dos estaciones de monitoreo y marcaje a largo plazo en el Norte-centro de Nuevo México. Las concentraciones de plomo sanguíneo, la actividad ALAD de los eritrocitos, y los niveles de hematocrito fueron identificados en adultos y juveniles emigrantes de otoño ($N = 45$ y 15 , respectivamente), y adultos migrantes de primavera ($N = 38$; ningún juvenil fue capturado en la sesión de primavera). Las concentraciones de plomo en la sangre de los adultos migratorios de primavera ($\bar{x} = 0.063 \pm \text{ES } 0.011 \mu\text{g/g}$) fue incre-

¹ E-mail address: toby.mcbride@tiehh.ttu.edu

² Present address: National Parks Conservation Association, P.O. Box 1836, Yucca Valley, CA 92286 U.S.A.

mentando significativamente en comparación tanto con los adultos como con los juveniles de otoño ($0.032 \pm 0.003 \mu\text{g/g}$ y $0.028 \pm 0.004 \mu\text{g/g}$, respectivamente). Las concentraciones de plomo en la sangre no alcanzaron niveles suficientes para que inhibieran reconociblemente la actividad ALAD de los eritrocitos o deprimieran los niveles de hematocrito. Sin embargo, la actividad ALAD pareció depender de la edad, como actividad en los juveniles de otoño (74.9 ± 2.2 unidades) fue significativamente mas alta que para los adultos de otoño y primavera (63.0 ± 2.9 unidades y 54.0 ± 3.1 unidades, respectivamente). Los valores de hematocritos indicaron diferencias no detectables entre la estación de migración o la edad. Los resultados sugieren que los gavilanes de Cooper están expuestos a niveles ambientales más altos de plomo en su rango sur que en el del norte, aunque no en concentraciones conocidas que causen efectos lesivos a la salud.

[Traducción de César Márquez]

The toxicological risks to waterfowl from spent lead shot used in hunting are well documented (Bellrose 1959, Stout and Cornwell 1976, Zwank et al. 1985, Sanderson and Bellrose 1986), and have led to the elimination of lead-based ammunition used for waterfowl hunting in United States and Canada. Investigations have also assessed the dangers of lead-based ammunition in upland game and mammal hunting. A risk assessment of lead effects in upland-bird species concluded that lead is likely to accumulate in birds following accidental ingestion of lead shot (Kendall et al. 1996). Lead artifacts and sinkers have been ingested as grit in high hunting-use and high fishing-use areas (Burger et al. 1997, Lewis et al. 2001), resulting in prolonged release of lead within the gizzard. Game birds may also be injured or killed during hunting attempts, but remain uncollected in the field. Subsequently, scavengers and raptors may be exposed to lead contamination through ingestion of these incapacitated birds.

Investigations of expelled castings collected from two wild raptor populations in Spain found lead shot artifacts in 6% and 11% of those collected (Mateo et al. 2001). Prevalence as high as 70% was reported in Bald Eagle (*Haliaeetus leucocephalus*) castings in Utah (Platt 1976). Both of these cases indicate exposure from an array of food items. Lead toxicosis and exposure to lead shot have been recognized in a variety of wild raptors including eagles, goshawks, vultures, and kites (Garner 1991, Miller et al. 1998, Platt et al. 1999, Wayland et al. 1999, Mateo et al. 2001). Documented lead-artifact-induced mortalities of Golden Eagles (*Aquila chrysaetos*), Red-tailed (*Buteo jamaicensis*) and Rough-legged hawks (*Buteo lagopus*), and Peregrine (*Falco peregrinus*) and Prairie falcons (*Falco mexicanus*), species not known to rely heavily on waterfowl for prey items, further imply a secondary risk of lead toxicosis from upland-bird and mammal prey

(Locke and Friend 1992). Lead poisoning resulting from the ingestion of lead fragments in consumed carcasses likely contributed to the historic decline of the California Condor (*Gymnogyps californianus*; Pattee et al. 1990, Meretsky et al. 2000). More recently, lead contamination has impacted the condor reintroduction program with the deaths of at least four birds in northern Arizona (Cilek et al. 2000) caused ostensibly by lead-artifact ingestion.

Lead toxicity induces effects on vascular, nervous, renal, immune, reproductive, and hemato-poietic systems, as well as behavioral abnormalities (Eisler 1988, Burger 1995). At lower tissue concentrations, several biomarkers have been used to assess sublethal effects. Delta-aminolevulinic-acid dehydratase (ALAD) is a widely studied, heme-related enzyme that is altered by lead contamination at low exposure levels. This zinc-dependent enzyme is easily inhibited by lead substitution and has been extensively characterized as a sensitive indicator of low-level lead exposure (Hoffman et al. 1981, Goering et al. 1986, Scheuhammer 1987, Pain 1996, McBride 2002). With increased exposure and ALAD inhibition, detrimental health effects may occur with decreases in hemoglobin production and erythrocyte concentrations. Blood-sample collection and analysis, thus, provides a sensitive, non-lethal means for monitoring health effects and lead-body burden.

Cooper's Hawks (*Accipiter cooperii*) are a medium-sized raptor, breeding throughout much of the United States, southern Canada, and northern Mexico. Inhabiting primarily coniferous and mixed forests (Rosenfield and Bielefeldt 1993), they can become habituated to human disturbance and may use urban and suburban areas that provide appropriate habitat (Stahlecker and Beach 1979, Boal and Mannan 1999). Cooper's Hawks routinely feed on avian prey as a primary food

source, with small game birds such as dove (e.g., *Zenaidura* spp.) and quail (e.g., *Colinus virginianus*) being potential prey (Rosenfield and Bielefeldt 1993, Boal 1997). This places the hawks at risk of ingesting spent-lead shot imbedded in injured game birds. Consequently, the Cooper's Hawk is a species of primary concern for lead exposure due to its predation on upland game birds (Kendall et al. 1996).

Migratory Cooper's Hawks are regularly captured for biological data collection each yr at two long-term monitoring and banding stations in north-central New Mexico (Hoffman et al. 2002). We investigated lead exposure and related health effects in the breeding and wintering ranges of migratory Cooper's Hawks by sampling their southward and northward migrating populations, respectively, at these sites.

STUDY AREA AND METHODS

Cooper's Hawks were trapped during migration at two relatively close research sites in the Cibola National Forest of north-central New Mexico. Blood sampling occurred during normal processing of captured birds for banding and data collection. Samples were collected at the Manzano Mountains station (34°42.25'N, 106°24.67'W) during fall migration from 15 September–21 October 2001 and at the Sandia Mountains station (35°05.21'N, 106°25.93'W) during spring migration from 11–14 April 2002. These two sites are located ca. 40 km apart along the same migratory-flight path, and have been situated to better sample migrants during each respective season. Samples were taken from all birds captured, regardless of gender or age class.

Migrating birds were trapped using captive lure birds and an assortment of bow-nets, dho-gaza traps, and mist nets (Hoffman et al. 2002). Blood samples were collected nonlethally via brachial veni-puncture, and separated into aliquots of ca. 150 μ l for ALAD activity determinations, with the remaining sample stored in chemically clean vials for metal analysis. Samples were packed in ice and returned to lab facilities where they were stored at -80°C until analysis. Packed cell volumes (PCVs) of the samples were determined at the time of collection using 100 μ l microhematocrit capillary tubes.

Sample preparation for lead analysis used a modification of U.S. Environmental Protection Agency (1996) method No. 3050B. Blood samples were placed in Teflon beakers and digested with 5 ml nitric acid on 120°C hot plates. Upon complete digestion, the nitric acid was evaporated to ca. 1–2 ml. Aliquots of 1.5 ml hydrogen peroxide (30%) were added and the samples were heated until fully reacted. Samples were transferred to 10 ml volumetric flasks and brought up to final volume using ultra-pure (MilliQ®, Millipore, Billerica, MA U.S.A.) water

All samples were analyzed for lead utilizing a Perkin Elmer® (Perkin Elmer, Wellesley, MA U.S.A.) AAnalyst 600 atomic absorption spectrophotometer with graphite

furnace (GFAA) and all data captured by Perkin Elmer® AAWinLab (version 3.71) instrument control software. Five-point calibration curves were developed using traceable NIST standards. The method-detection limit for lead in blood samples, on a wet-weight basis, was $0.034 \mu\text{g Pb/g}$ blood. Samples falling below the detection limit (BDL) were assigned a value of one-half the detection limit ($0.017 \mu\text{g/g}$).

Erythrocyte ALAD enzyme activity was measured using a modification of Pain (1987). Three 25 μ l aliquots of previously frozen whole blood were each added to 725 μ l ultra-pure water prior to incubation. The assay was started by the addition of 500 μ l of δ -aminolevulinic acid (ALA; 100 mM final concentration, or FC) in sodium phosphate buffer (pH 6.4), and incubated in the 38°C water bath for 1 hr. Enzyme activity was halted with the addition of 500 μ l of trichloroacetic acid solution (612 mM FC). Precipitated proteins were separated by centrifugation (2000 rpm for 10 min) and 100 μ l aliquots of the supernatant solution containing the reaction product, porphobilinogen, were pipetted into the appropriate wells of a 96-well microtiter plate. Ehrlich's indicator reagent (100 μ l) was then added to each well, which was then covered and analyzed immediately. Absorbance was read every min for 10 min, at 555 nm (kinetic mode) using a SPECTROMax Plus 96-well spectrophotometric plate reader controlled by Molecular Devices® SOFTmax Pro software (Molecular Devices Corp., Sunnyvale, CA U.S.A.). The maximum value (background corrected) was selected for use in the activity determination. Enzyme activity was calculated using the equation:

$$\text{Activity} = (11\,580 \times \text{Max. Absorbance}_{555}) / \text{Hematocrit}$$

where 11 580 is a conversion factor based on the molar-extinction coefficient specific to the porphobilinogen/*p*-dimethylaminobenzaldehyde complex ($62\,000 \text{ M}^{-1} \text{ cm}^{-1}$), as well as stoichiometric calculations and dilution factors. Max. Absorbance₅₅₅ was measured in absorbance units and Hematocrit was expressed as a percent. ALAD activity units were expressed as nmoles ALA \times min⁻¹ \times ml RBC⁻¹.

Statistical analyses were performed using SigmaStat for Windows (Jandel Corporation, SPSS Inc., Chicago, IL U.S.A.). Hematocrit values and ALAD activity were analyzed for significant differences between ages and between migration seasons using a one-way analysis of variance (ANOVA). Blood-lead concentrations were not normally distributed due to numerous samples assigned the BDL value of one-half the detection limit. Therefore, data sets were tested using a Kruskal-Wallis analysis of ranks test. No sex-dependent differences were identified for any of the tested parameters ($P \geq 0.28$); thus, genders were combined for the final statistical analyses. Linear regression equations were calculated to examine the relationships between detectable blood-lead concentrations and ALAD activity. For all tests, results were considered significant if $P \leq 0.05$.

RESULTS

We collected 98 blood samples over the two migratory seasons. We collected 60 samples during fall migration: 15 from juveniles, 45 from adults

(Fig. 1A). We collected 38 samples from adults during spring migration. We were unable to capture any juveniles during the spring collection period. Fall juvenile lead concentrations varied from 0.017 (half detection limit) to 0.071 $\mu\text{g/g}$ ($\bar{x} = 0.028 \pm \text{SE } 0.004 \mu\text{g/g}$, median = 0.017 $\mu\text{g/g}$). Only six of 15 samples were above detectable limits ($\bar{x} = 0.045 \pm 0.005 \mu\text{g/g}$). Fall adult lead concentrations varied from 0.017 to 0.112 $\mu\text{g/g}$ ($\bar{x} = 0.032 \pm 0.003 \mu\text{g/g}$, median = 0.017 $\mu\text{g/g}$). Nineteen of 45 values were above detectable limits ($\bar{x} = 0.052 \pm 0.004 \mu\text{g/g}$). Spring adult values ($N = 38$) varied from 0.017 (half detection limit) to 0.356 $\mu\text{g/g}$ ($\bar{x} = 0.063 \pm 0.011 \mu\text{g/g}$, median = 0.047 $\mu\text{g/g}$). Twenty-five of 38 values were above detectable limits ($\bar{x} = 0.086 \pm 0.015 \mu\text{g/g}$). Blood-lead levels showed significant variation between migration season and age ($P = 0.005$), with higher concentrations in spring adults than either fall adults or fall juveniles.

Due to storage and volume constraints, only 47 of 98 (46%) blood samples were analyzed for erythrocyte ALAD enzyme activity (Fig. 1B). Fall juvenile samples ($N = 9$) showed activities ranging from 67.2–84.2 units ($\bar{x} = 74.9 \pm 2.2$ units). Fall adult samples ($N = 20$) showed activities ranging from 43.8–100 units ($\bar{x} = 63.0 \pm 2.9$ units). Spring adult samples varied from 16.4–67.1 units ($\bar{x} = 54.0 \pm 3.1$ units). Enzyme activity appeared to be age-dependent; fall juvenile values were significantly higher than fall adult and spring adult values ($P = 0.001$). Further, spring adult ALAD enzyme activity was reduced 28% and 14% when compared to fall juvenile and fall adult samples, respectively.

We assessed packed cell volumes for 58 of 98 (59%) blood samples (Fig. 1C). Fall juvenile values ($N = 10$) varied from 42–48% ($\bar{x} = 45.9\% \pm 0.6$). Fall adult hematocrit values ($N = 20$) varied from 41–50% ($\bar{x} = 46.4\% \pm 0.5$). Values for spring adult samples ($N = 28$) ranged from 37–56% ($\bar{x} = 47.6\% \pm 1.0$). Packed cell volumes did not vary significantly between seasons or ages.

In examining the relationship between blood-lead concentration and health effects, individual-ALAD activity was regressed as a function of corresponding blood-lead concentration. However, only 2% of the variability in enzyme activity could be explained by the concentration of lead in the blood ($r^2 = 0.02$).

DISCUSSION

Blood-lead levels in Falconiformes are considered "subclinical" at levels between 0.2 and 1.5

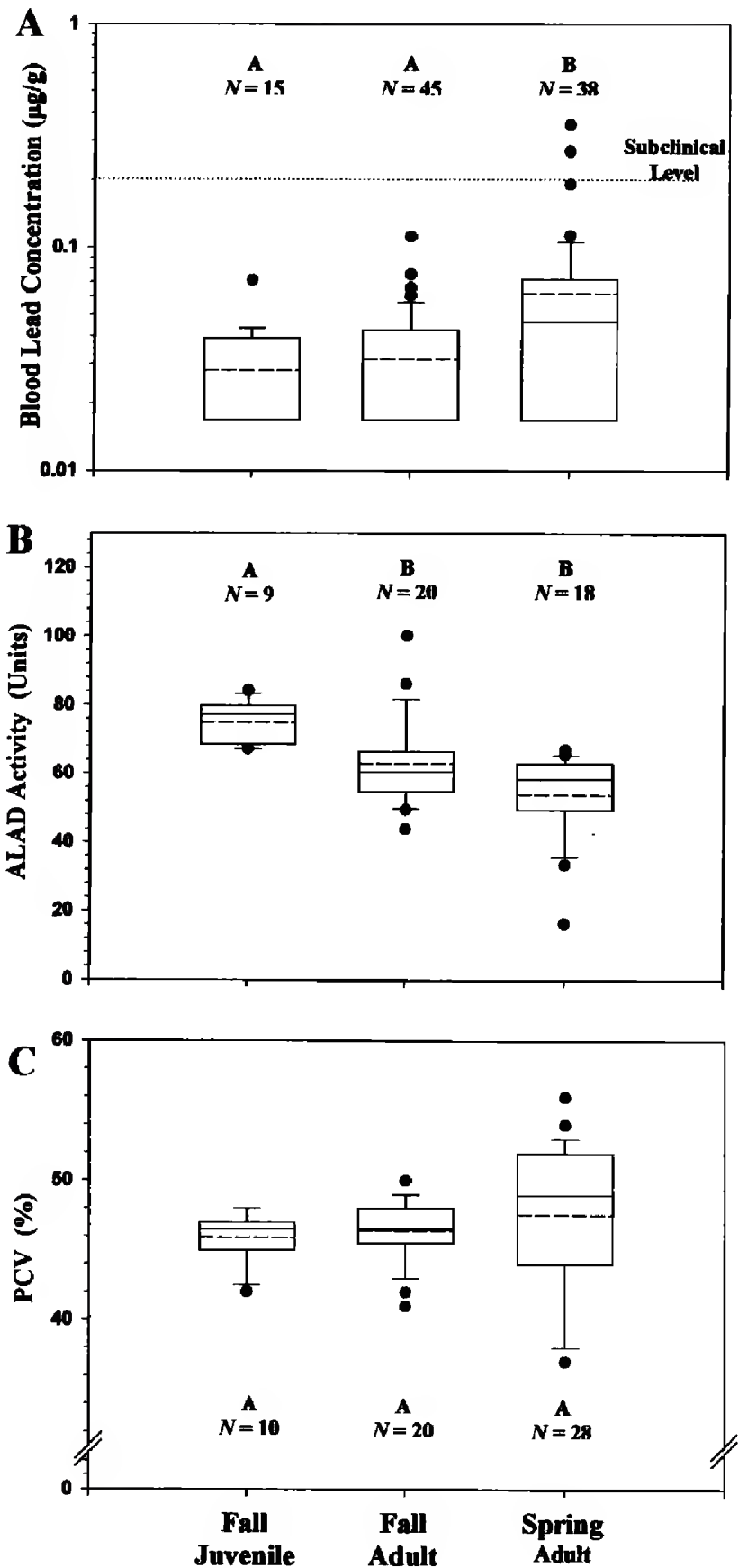


Figure 1. A. Blood-lead concentration ($\mu\text{g/g}$) of juvenile and adult Cooper's Hawks during fall and spring migration. Mean (dashed line), median (solid line), 25th and 75th percentiles (box limits), standard deviation (error bars), and outliers (individuals points) of blood-lead concentrations. Subclinical effects level (Franson 1996) indicated for reference. Groups with the same letter in common are not significantly different ($P \leq 0.05$). B. ALAD enzyme activity in juvenile and adult Cooper's Hawks during migration. C. Hematocrit values of juvenile and adult Cooper's Hawks during migration.

$\mu\text{g/g}$ (Franson 1996). These levels are elevated above background concentrations (defined as $<0.2 \mu\text{g/g}$) and are indicative of initiating physiological effects (Franson 1996). In all, three of 98 (3%) blood samples analyzed equaled or exceeded this background level, with all such samples collected during spring migration. Though the majority of Cooper's Hawks tested demonstrated little evidence of significant lead intoxication, these three individuals exhibited sufficiently increased blood-lead concentrations that suggested exposure to either contaminated food items or ingestion of lead artifacts. Mallards (*Anas platyrhynchos*) dosed with a single No. 4 shot exhibited similar blood-lead levels of $0.317 \mu\text{g/g}$ 1 mo post-dose, and $0.207 \mu\text{g/g}$ 3 mo post-dose (Dieter and Finley 1978), demonstrating the potential for blood concentrations to stay elevated for extended periods from a single lead-artifact exposure. In acute exposure, ingested lead quickly equilibrates between blood and soft tissues, remaining elevated in both for several weeks to months following exposure (Pain 1996). Blood-lead concentrations may take up to 4 mo to return to normal levels (Dieter and Finley 1978), thus the potential exists that the three notable Cooper's Hawks had much higher blood-lead levels prior to leaving for their northward migration.

Increased blood-lead levels during spring migration indicated that Cooper's Hawks migrating along the central Rocky Mountain Flyway were being exposed to higher environmental lead levels while in their winter ranges (specifically southern New Mexico, southwest Texas, and northwest Mexico; Hoffman et al. 2002). Hunting seasons for most avian and mammal game species occur during late fall and winter in the United States and Mexico. Thus, risk of exposure for these raptors to spent-lead shot likely increases in their wintering range and may explain higher blood-lead levels in spring migrant hawks. Interestingly, an analysis of Cooper's Hawk banding data from several western migration sites showed that more than half of the banded hawks recovered during winter had been shot, with the majority recovered in Mexico (Hoffman et al. 2002). This suggests that wintering Cooper's Hawks occupy an environment where the risk of direct hunting injury as well as secondary lead contamination may be higher than during their breeding season.

Due to the historic use of lead in gasoline and its presence in industrial waste, lead is ubiquitous throughout the environment, resulting in back-

ground levels that may be detected in almost all animal tissues (Eisler 1988). Cooper's Hawks may inhabit urban centers that provide habitat (Boal and Mannan 1999), and may be exposed to increased environmental lead as a result of localized anthropogenic sources. Increased exposure to lead in urban areas has been noted in several avian species, including Rock Pigeon (*Columba livia*), European Starlings (*Sturnus vulgaris*), House Sparrows (*Passer domesticus*), and American Robins (*Turdus migratorius*; Getz et al. 1977, Kendall and Scanlon 1982, Grue et al. 1986), all potential prey species of Cooper's Hawks (Rosenfield and Bielefeldt 1993). Increased tissue-lead concentrations also have been noted in other urban-dwelling avian predators, including Peregrine Falcons (DeMent et al. 1986). Even without the risks associated with eating hunter-injured prey items, Cooper's Hawks inhabiting urban centers would likely be exposed to lead-contaminated food items.

The inhibition of erythrocyte ALAD activity is a well-established biochemical alteration associated with lead exposure in birds (Hoffman et al. 1985, Beyer et al. 1985, Henny et al. 1991). Nestling American Kestrels (*F. sparverius*) exhibited ALAD inhibition at $0.12 \mu\text{g/g}$ (McBride 2002), and showed 55% ALAD activity inhibition with mean blood-lead levels of $0.25 \mu\text{g/g}$ (Henny et al. 1994). The 14–28% reduction in ALAD activity seen between fall and spring migrants is feasibly influenced by lead-induced-enzyme depression. With greater sampling, we would expect to see a dose-dependent decrease in enzyme activity occurring at lead levels greater than the background threshold of $0.2 \mu\text{g/g}$ established by Franson (1996). The generally low blood-lead levels likely obscured an identifiable dose-response inhibition of ALAD activity, as the lowest ALAD activities detected did not correlate to the three notable high blood-lead individuals.

Levels of enzyme inhibition seen were not indicative of levels sufficient to significantly inhibit erythrocyte production (Fig. 1C). Franson et al. (1983) noted no significant change in hematocrit of American Kestrels dosed with 50 ppm of lead in the diet for 5 mo, despite a 20% ALAD inhibition. Hematocrits of breeding Cooper's Hawks in Arizona (male: $\bar{x} = 53.7\%$; female: $\bar{x} = 50.7\%$; Boal et al. 1998) were higher than fall-migrating Cooper's Hawks captured in Utah ($\bar{x} = 49.2\% \pm 2.6$; Gessaman et al. 1986), suggesting a potential seasonally or reproductively-induced fluctuation; how-

ever, no seasonal differences were identified in this study.

This study is the first effort in an investigation of secondary exposure to lead-based ammunition and lead-based fishing sinkers in raptors, and will be followed by further assessments of other migratory and nonmigratory raptors from other major U.S. migratory flyways. In a similar investigation of migrating Sharp-shinned Hawks (*Accipiter striatus*) in the eastern United States (Pennsylvania and New Jersey), liver-lead concentrations from 19 individuals ($\bar{x} = 0.007 \mu\text{g/g}$ wet weight) were found to be within background levels, indicating little accumulation risk for this related species (Bohall-Wood et al. 1996). Though migratory Cooper's Hawks do not appear to be at significant risk from lead-artifact ingestion in the Rocky Mountain Flyway, hunting practices and density vary widely in the U.S. and the potential for increased exposure resulting from greater hunting and fishing pressures in other regions of the country exists. Additionally, individuals experiencing higher exposure levels may be precluded from successful migration, and may not be identified in studies such as these. Further investigation of a greater variety of raptor species is required before an assessment of the true risks to raptors will be possible.

ACKNOWLEDGMENTS

HawkWatch International banding crews in the Sandia Mountains (A. Peterson, C. Noel Nies, and W. Lehman) and Manzano Mountains (R. Smith, K. Jacobson, D. Johnson, K. Bagnall, L. Greenwood, and P. McKann) assisted with animal capture, handling, and sample collections. M. Baird and C. McFarland assisted with laboratory analyses. P. Grindrod and W. Sanborn provided useful editorial comments. The project described was supported in part by grant No. P42 ES04696 from the National Institute of Environmental Health Sciences, NIH. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the NIEHS or NIH. Funding to support the HawkWatch International banding projects was provided by Cibola National Forest, New Mexico Game and Fish—Share with Wildlife Program, Intel Corporation, U.S. Fish and Wildlife Service—Region 2, National Fish and Wildlife Foundation, LaSalle Adams Fund, Bureau of Reclamation—Upper Colorado Region, Kerr Foundation, New Belgium Brewing Co., Central New Mexico Audubon, and HawkWatch International members.

LITERATURE CITED

- BELLROSE, F.C. 1959. Effects of ingested lead shot upon waterfowl populations. *Trans. N.A. Wildl. Conf.* 16:123–135.
- BEYER, W.N., O.H. PATTEE, L. SILEO, D.J. HOFFMAN, AND B.M. MULHERN. 1985. Metal contamination in wildlife living near two zinc smelters. *Environ. Pollut.* 38:63–86.
- BOAL, C.W. 1997. An urban environment as an ecological trap for Cooper's Hawks. Dissertation, Univ. Arizona, Tucson, AZ U.S.A.
- , K.S. HUDELSON, R.W. MANNAN, AND T.S. ESTABROOK. 1998. Hematology and hematozoa of adult and nestling Cooper's Hawks in Arizona. *J. Raptor Res.* 32:281–285.
- AND R.W. MANNAN. 1999. Comparative breeding ecology of Cooper's Hawks in urban and exurban areas of southeastern Arizona. *J. Wildl. Manage.* 63:77–84.
- BOHALL-WOOD, P., C. VIVERETTE, L. GOODRICH, M. POKRAS, AND C. TIBBOTT. 1996. Environmental contaminant levels in Sharp-shinned Hawks from the eastern United States. *J. Raptor Res.* 30:136–144.
- BURGER, J. 1995. A risk assessment for lead in birds. *J. Toxicol. Environ. Health* 45:369–396.
- , R.A. KENNAMER, I.L. BRISBIN, AND M. GOCHFELD. 1997. Metal levels in Mourning Doves from South Carolina: potential hazards to doves and hunters. *Environ. Res.* 75:173–186.
- CIEK, J., J. HUMPHREY, P. O'BRIEN, AND B. ARIAL. 2000. Four California Condors dead. California Condor Recovery Team press release. 10 November 2002, www.peregrinefund.org/press/con0700.html.
- DEMENT, S.H., J.J. CHISHOLM, JR., J.C. BARBER, AND J.D. STRANDBERG. 1986. Lead exposure in an "urban" Peregrine Falcon and its avian prey. *J. Wildl. Dis.* 22:238–244.
- DIETER, M.P. AND M.T. FINLEY. 1978. Erythrocyte d-aminolevulinic acid dehydratase activity in Mallard Ducks duration of inhibition after lead shot dosage. *J. Wildl. Manage.* 42:621–625.
- EISLER, R. 1988. Lead hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish Wildl. Serv. Biol. Rep. 85(1.14). U.S. Fish Wildl. Serv. Laurel, MD U.S.A.
- FRANSON, J.C. 1996. Interpretation of tissue lead residues in birds other than waterfowl. Pages 341–356 in W.N. Beyer, G.H. Heinz, and A.W. Redmon-Norwood [Eds.], *Environmental contaminants in wildlife*. Lewis Publishers, Boca Raton, FL U.S.A.
- , L. SILEO, O.H. PATTEE, AND J.F. MOORE. 1983. Effects of chronic dietary lead in American Kestrels (*Falco sparverius*). *J. Wildl. Dis.* 19:110–113.
- GARNER, M. 1991. Suspected lead toxicosis in a captive goshawk. *J. Am. Vet. Med. Assoc.* 199:1069–1070.
- GESSAMAN, J.A., J.A. JOHNSON, AND S.W. HOFFMAN. 1986. Hematocrits and erythrocyte number for Cooper's and Sharp-shinned Hawks. *Condor* 88:95–96.
- GETZ, L.L., L.B. BEST, AND M. PRATHER. 1977. Lead in urban and rural songbirds. *Environ. Pollut.* 12:235–238.
- GOERING, P.L., P. MISTRY, AND B.A. FOWLER. 1986. A low

- molecular weight lead-binding protein in brain attenuates lead inhibition of aminolevulinic acid dehydratase: comparison with a renal lead-binding protein. *J. Pharm. Exper. Therap.* 237:220–225.
- GRUE, C.E., D.J. HOFFMAN, W.N. BEYER, AND L.P. FRANSON. 1986. Lead concentrations and reproductive success in European Starlings (*Sturnus vulgaris*) nesting within highway roadside verges. *Environ. Pollut.* 42:157–182.
- HENNY, C.J., L.J. BLUS, D.J. HOFFMAN, AND R.A. GROVE. 1991. Lead accumulation and Osprey production near a mining site on the Coeur d'Alene River, Idaho. *Arch. Environ. Contam. Toxicol.* 21:415–424.
- , L.J. BLUS, D.J. HOFFMAN, AND R.A. GROVE. 1994. Lead in hawks, falcons and owls downstream from a mining site on the Coeur d'Alene River, Idaho. *Environ. Monit. Assess.* 29:267–288.
- HOFFMAN, D.J., O. PATTEE, S.N. WIEMEYER, AND B. MULHERN. 1981. Effects of lead shot ingestion on aminolevulinic acid dehydratase activity, hemoglobin concentration, and serum chemistry in bald eagles. *J. Wildl. Dis.* 17:423–431.
- , J.C. FRANSON, O.H. PATTEE, C.M. BUNCK, AND H.C. MURRAY. 1985. Biochemical and hematological effects of lead ingestion in nestling American Kestrels. *Comp. Biochem. Physiol.* 80C:431–439.
- HOFFMAN, S.W., J.P. SMITH, AND T.D. MEEHAN. 2002. Breeding grounds, winter ranges, and migratory routes of raptors in the mountain west. *J. Raptor Res.* 36:97–110.
- KENDALL, R.J. AND P.F. SCANLON. 1982. Tissue lead concentrations and blood characteristics of Rock Doves from an urban setting in Virginia. *Arch. Environ. Contam. Toxicol.* 11:265–268.
- , T.E. LACHER, C. BUNCK, B. DANIEL, C. DRIVER, C.E. GRUE, F. LEIGHTON, W. STANSLEY, P.G. WATANBE, AND M. WHITWORTH. 1996. An ecological risk assessment of lead shot exposure in non-waterfowl avian species: upland game birds and raptors. *Environ. Toxicol. Chem.* 15:4–20.
- LEWIS, L.A., R.J. POPPENGA, W.R. DAVIDSON, J.R. FISCHER, AND K.A. MORGAN. 2001. Lead toxicosis and trace element levels in wild birds and mammals at a firearm training facility. *Arch. Environ. Contam. Toxicol.* 41:208–214.
- LOCKE, L.N. AND M. FRIEND. 1992. Lead poisoning of avian species other than waterfowl. Pages 19–22 in D.J. Pain [ED.], Lead poisoning in waterfowl. Waterfowl Wetlands Research Bureau, Slimbridge, Gloucester, U.K.
- MATEO, R., R. CADENAS, M. MAÑEZ, AND R. GUITART. 2001. Lead shot ingestion in two raptor species from Doñana, Spain. *Ecotoxicol. Environ. Saf.* 48:6–10.
- MCBRIDE, T.J. 2002. Metal exposure and effects in American Kestrel nestlings raised on a smelter-impacted Superfund site. M.S. thesis, Texas Tech University, Lubbock, TX U.S.A.
- MERETSKY, J.V., F.N. SNYDER, AND R.S. BEISSINGER. 2000. Demography of the California Condor: implications for reestablishment. *Conserv. Biol.* 14:957–967.
- MILLER, M.J.R., M. RESTANI, A.R. HARMATA, G.R. BORTOLLOTTI, AND M.E. WAYLAND. 1998. A comparison of blood-lead levels in Bald Eagles from two regions on the great plains of North America. *J. Wildl. Dis.* 34:704–714.
- PAIN, D.J. 1987. Lead poisoning in waterfowl: an investigation of sources and screening techniques. Dissertation, Univ. of Oxford, Oxford, U.K.
- . 1996. Lead in waterfowl. Pages 251–295 in W.N. Beyer, G.H. Heinz, and A.W. Redmon-Norwood [EDS.], Environmental Contaminants in Wildlife. Lewis Publishers, Boca Raton, FL U.S.A.
- PATTEE, O.H., P.H. BLOOM, J.M. SCOTT, AND M.R. SMITH. 1990. Lead hazards within the range of the California Condor. *Condor* 92:931–937.
- PLATT, J.B. 1976. Bald Eagles wintering in a Utah desert. *Am. Birds* 30:783–788.
- PLATT, S.R., K.E. HELMICK, J. GRAHAM, R.A. BENNETT, L. PHILLIPS, C.L. CHRISMAN, AND P.E. GINN. 1999. Peripheral neuropathy in a Turkey Vulture with lead toxicosis. *J. Am. Vet. Med. Assoc.* 214:1218–1220.
- ROSENFELD, R.N. AND J. BIELEFELDT. 1993. Cooper's Hawk (*Accipiter cooperii*). In A. Poole and F. Gill [EDS.], The birds of North America, No. 75. Birds of North America, Inc., Philadelphia, PA U.S.A.
- SANDERSON, G.C. AND F.C. BELLROSE. 1986. A review of the problem of lead poisoning of waterfowl: special publications 4. Illinois Natural History Survey, Campaign, IL U.S.A.
- SCHEUHAMMER, A.M. 1987. The chronic toxicity of aluminum, cadmium, mercury, and lead in birds: a review. *Environ. Pollut.* 46:263–295.
- STAHLECKER, D.W. AND A. BEACH. 1979. Successful nesting by Cooper's Hawks in an urban environment. *Inland Bird Banding* 51:56–57.
- STOUT, I.J. AND G.W. CORNWELL. 1976. Nonhunting mortality of fledged North American waterfowl. *J. Wildl. Manage.* 44:525–527.
- UNITED STATES ENVIRONMENTAL PROTECTION AGENCY. 1996. Method 3050B: acid digestion of sediments, sludges, and soils. 10 November 2002, www.epa.gov/epaoswer/hazwaste/test/pdfs/3050b.pdf.
- WAYLAND, M., E. NEUGEBAUER, AND T. BOLLINGER. 1999. Concentrations of lead in liver, kidney, and bone of Bald and Golden eagles. *Arch. Environ. Contam. Toxicol.* 37:267–272.
- ZWANK, P.J., V.L. WRIGHT, P.M. SIEALY, AND J.D. NELSON. 1985. Lead toxicosis in waterfowl on two major wintering areas in Louisiana. *Wildl. Soc. Bull.* 13:17–26.

Received 1 April 2003; accepted 23 November 2003
Associate Editor: Clint W. Boal

AN ASSESSMENT OF CAGE FLIGHT AS AN EXERCISE METHOD FOR RAPTORS

DANA M. GREENE¹

Department of Biology, University of North Carolina, Charlotte, NC 28223 U.S.A.

MATHIAS ENGELMANN

Carolina Raptor Center, P.O. Box 16443, Charlotte, NC 28297 U.S.A.

TODD R. STECK²

Department of Biology, University of North Carolina, Charlotte, NC 28223 U.S.A.

ABSTRACT.—There are a number of methods used for exercising muscles during the rehabilitation of raptors, such as outdoor-creance flight, indoor-hall flight, outdoor-cage flight, and combinations of any of the above. Previous studies measured blood-lactate levels after cessation of exercise to assess muscle fitness and found that creance flight was an effective means of exercise. Physical fitness was inversely correlated with the time it took for postexercise blood-lactate levels to decrease. Using criterion for muscle fitness previously established for creance flight, we examined the effectiveness of caged flight to increase muscle fitness during rehabilitation of six species of raptors: Barn Owl (*Tyto alba*), Barred Owl (*Strix varia*), Broad-winged Hawk (*Buteo platypterus*), Eastern Screech-Owl (*Megascops asio*), Great Horned Owl (*Bubo virginianus*), and Red-tailed Hawk (*Buteo jamaicensis*). Examination of blood-lactate levels after exercise indicated that caged flight may be sufficient to increase muscle fitness in Great Horned Owls and Broad-winged Hawks and may be a useful method to increase muscle fitness in three of the remaining four raptor species examined. However, there was a difference in the recovery of lactate values related to the type of injury and species of raptor injured, suggesting the effectiveness of flight cages are species specific and that additional rehabilitation techniques, as well as longer rehabilitation durations may be needed for full recovery.

KEY WORDS: *Raptor rehabilitation; muscle fitness; cage-flight exercise; creance-flight exercise.*

UNA EVALUACIÓN DE LAS ENCIERROS DE VUELO COMO UN METODO DE EJERCICIO PARA AVES RAPACES

RESUMEN.—Hay un número de métodos usados para ejercitar los músculos durante la rehabilitación de rapaces, tales como el vuelo con fiador en exteriores, el vuelo en un salón interior, el vuelo en un encierro exterior, y combinaciones de algunos de los anteriores. Estudios previos han medido los niveles de lactato en la sangre luego de cesar el ejercicio para evaluar la aptitud del músculo y encontraron que el vuelo con fiador fue un medio efectivo de ejercicio. La aptitud física fue correlacionada inversamente con el tiempo invertido para que los niveles de lactato en la sangre decrecieran después del ejercicio. Usando un estándar para la aptitud del músculo establecida previamente para el vuelo con fiador, examinamos la efectividad del vuelo en jaula para aumentar la aptitud del músculo durante la rehabilitación de seis especies de rapaces: Lechuzas (*Tyto alba*), búhos barrados (*Strix varia*), gavilanes de ala ancha (*Buteo platypterus*), búhos chirreadores orientales (*Megascops asio*), el gran búho cornado (*Bubo virginianus*), y gavilanes de cola roja (*Buteo jamaicensis*). El examen de los niveles de lactato en la sangre después del ejercicio indicó que el vuelo en jaulas puede ser suficiente para incrementar la aptitud del músculo en búhos cornados y gavilanes de ala ancha y puede ser un método útil para incrementar la aptitud del músculo en tres de las restantes cuatro especies de aves rapaces examinadas. Sin embargo, no hubo diferencia en la recuperación de los valores de lactato relacionado con el tipo de lesión y la especie de ave rapaz herida, sugiriendo que la efectividad de las jaulas de vuelo es

¹ Present address: University of Alaska Fairbanks, 902 Koyukuk Drive, Fairbanks, AK 99775 U.S.A.

² Corresponding author's email address: trsteck@email.uncc.edu

especifica a la especie y que las técnicas de rehabilitación adicionales, al igual que los tiempos de rehabilitación mas extensos pueden ser necesarios para una recuperación total.

[Traducción de César Márquez]

The goal of raptor rehabilitation is to treat, rehabilitate, and release injured birds of prey into the wild. During convalescence, the skeletal-muscle fitness of a raptor can significantly decline. To improve survival after release, muscle fitness should be restored to a degree that would allow a raptor to hunt successfully. However, there is little known about the effectiveness of various exercise methods used by rehabilitators.

Several main methods are used for exercising muscles during the rehabilitation of raptors (Chaplin et al. 1989). Hall flights are performed indoors with the bird flying unrestrained from one perch to another and usually these short flights are repeated several times. Creance flight is performed by attaching a tether to leather anklets placed on the bird's legs. The bird is then taken out into a large open field and allowed to fly the length of the tether a number of times as determined by the rehabilitator. Chaplin et al. (1989, 1993) established that creance flight increases the flight fitness of injured raptors. Hall flight and creance flight are often used together, starting first with hall flights and progressing to creance flight. Another method for rehabilitation is outdoor-cage flights. A raptor that has healed from its injury is placed in an outdoor-flight cage to build muscle strength initially by moving between low perches. Once the raptor is able to move easily between these perches without signs of stress (i.e., panting), it is then moved to a larger flight cage. Flight cages are usually long and narrow with high perches only at the ends in order to encourage full flights from one perch to the next. The cages are also built to species-specific dimensions (Read 1990). Unlike creance flight, there have been no studies examining the effectiveness of outdoor-cage flight.

Wildlife rehabilitation principles include limiting human contact to prevent habituating birds to humans to improve their success as independent predators in the wild, and to reduce stress from human contact (Patton and Crawford 1985). There are certain advantages and disadvantages associated with each of the exercise methods mentioned above. The advantages of cage flight are that a bird is handled much less than with creance flight, multiple birds can be exercised at one time and by one

rehabilitator, and the exercise can be completed in a matter of minutes. This is beneficial to rehabilitation facilities dependent upon trained volunteers and a limited staff. However, an advantage of creance flight may be that it allows for longer continuous flight, up to 60 m or more, and construction of flight cages is not required.

Evaluating these exercise methods requires a means to assess exercise effectiveness. One assessment tool used to measure the physical fitness of raptors during their exercise regimen is based on physical fitness being inversely correlated with the time it takes for postexercise blood-lactate levels to decrease (Persson 1983). Lactate is a good indicator of overall skeletal-muscle fitness because it reflects how efficiently the animal is converting glucose into energy (Persson 1983). Lactate is increased during exercise when skeletal muscles are forced, by a lack of oxygen, to undergo anaerobic respiration.

The kinetics of the change in blood-lactate levels during and after exercise have been used to investigate the effectiveness of creance flight as a method for rehabilitation of Red-tailed Hawks (*Buteo jamaicensis*; Chaplin et al. 1989, Mueller and Chaplin 1990). Skeletal-muscle fitness was examined by quantifying the lactate concentration present in the blood at 2-min and 10-min postexercise. These workers found that over a 2–5 wk exercise regimen, Red-tailed Hawks had a decrease in the overall lactate concentration present in the blood postexercise, indicating that skeletal-muscle fitness was improving. A follow-up study using similar criteria found that creance flight was an effective means of rehabilitation for seven additional species of raptors: Northern Saw-whet Owl (*Aegolius acadicus*), Eastern Screech-Owl (*Megascops asio*), Long-eared Owl (*Asio otus*), Barred Owl (*Strix varia*), Great Horned Owl (*Bubo virginianus*), American Kestrel (*Falco sparverius*), and Northern Harrier (*Circus cyaneus*; Chaplin et al. 1993). As part of Chaplin's et al. (1993) research, the basal-lactate levels for these species of raptor were established for differing levels of exercise using creance flight.

Using the muscle-fitness-evaluation method described by Chaplin et al. (1989), we examined the effectiveness of cage flight to improve the fitness

Table 1. Injuries of raptors used in the study.

RAPTOR SPECIES	INJURY TYPE
Broad-winged Hawks (<i>N</i> = 4)	2 broken talons Old keel fracture, dehydration, bruising Left eye trauma, bruised left wing Orphaned, no injuries
Red-tailed Hawks (<i>N</i> = 7)	Fractured right wing (radius) Fractured right wing (humerus), emaciation Fractured left wing (ulna) Right eye trauma, fractured left tibiotarsus, emaciation Tissue damage left leg, emaciation Fractured right humerus Tissue damage right leg, emaciation
Barn Owls (<i>N</i> = 4)	Fractured left metacarpals Wound on right wrist Fractured left metacarpals, emaciation Orphaned, no injuries
Eastern Screech-Owls (<i>N</i> = 4)	Concussion Eye trauma (both eyes) Right eye trauma, concussion Unknown
Barred Owls (<i>N</i> = 2)	Fractured right ulna, right eye removed, left eye trauma Healed fracture left metatarsus, left eye trauma
Great Horned Owls (<i>N</i> = 4)	Orphaned, no injuries Orphaned, no injuries Emaciation, right leg wound, toe injuries Orphaned, no injuries

of injured Red-tailed Hawks, Broad-winged Hawks (*Buteo platypterus*), Eastern Screech-Owls, Barred Owls, Barn Owls (*Tyto alba*) and Great Horned Owls.

METHODS

Exercise Regimen. The injured and orphaned birds used in this study were admitted to the Carolina Raptor Center and confined to indoor cages for 3–30 wk during injury treatment (Table 1). Raptors were then placed in

small outdoor cages (3 m × 5 m × 3 m) containing multiple perches of varying heights (0.3–1.6 m tall). Birds were fed a diet of either rats (*Rattus norvegicus*) or mice (*Mus musculus*) 6 d/wk. They were moved to a flight cage after they were able to move among the low perches without difficulty, and based upon inspection of respiration and feather condition. Only raptors of the same species were housed together in flight cages, with 6–8 birds per cage. The flight cages were species specific (Table 2), and large enough to accommodate flight during the entire period of rehabilitation. The flight cages at the Car-

Table 2. Approximate cage and perch measurements for selected rehabilitation cages. Each species of raptor studied were housed in outdoor flight cages for the 3 wk of study. Dimensions within each cage are variable because ground slopes in most cases, leaving one end of the cage taller than the other. Perches represent the tallest available to birds and the ones they select most of the time while exercising.

RAPTOR HOUSED	CAGE DIMENSIONS	GROUND-TO-PERCH	PERCH-TO-CEILING
Broad-winged Hawks	14 m L × 3 m W × 3.5 m H	2.5 m	1 m
Barn Owls	17 m L × 3 m W × 3.5 m H	2.5 m	1 m
Barred Owls	17 m L × 3 m W × 3.5 m H	2.5 m	1 m
Eastern Screech-Owls	10.5 m L × 3 m W × 3 m H	2.5 m	0.5 m
Red-tailed Hawks	27.5 m L × 4.5 m W × 4.5 m H	3 m–3.5 m	1 m–1.5 m
Great Horned Owls	14 m L × 3 m W × 3.5 m H	2.5 m–3 m	1 m–1.5 m

Table 3. Slopes of lactate concentrations for six species of raptors with and without inclusion of orphans over a 3–5 wk exercise period. Raptor samples with no orphans are indicated with N/A.

RAPTOR SPECIES	DATA WITH ALL BIRDS		DATA WITHOUT ORPHANS	
	2-min	10-min	2-min	10-min
Red-tailed Hawks (<i>N</i> = 7)	–1.87	–6.79	N/A	N/A
Great Horned Owls (<i>N</i> = 4), no orphans (<i>N</i> = 1)	–12.02*	–15.28*	–16.18 ^a	–39.08 ^a
Barred Owls (<i>N</i> = 2)	10.25	12.63	N/A	N/A
Barn Owls (<i>N</i> = 4), no orphans (<i>N</i> = 3)	0.58	7.96	–5.48	5.74
Broad-winged Hawks (<i>N</i> = 4), no orphans (<i>N</i> = 3)	–22.04	3.44	–36.66*	0.24
Eastern Screech-Owls (<i>N</i> = 4)	–9.45	–4.12	N/A	N/A

* Indicates a significant decrease in lactate concentrations ($P \leq 0.05$).

^a Indicates no analysis was possible because there was only one Great Horned Owl in this group.

olina Raptor Center were built based upon the experience of the rehabilitators, and built as large as possible based on the birds' needs and available funding. The perches were situated high at opposite ends to encourage full flights the length of the cage (Table 2).

Once the birds acclimated to their surroundings (2–5 d), they were exercised daily by a rehabilitator walking from one end of the cage to the other end, encouraging the birds to fly. The numbers of flights were gradually increased by 2–5 flights per wk, depending on the species of raptor and the rehabilitator's opinion of the individual fitness of each bird at the beginning of the regimen. Respiratory rate, feather condition, and flight form were used as indices of physical fitness. Red-tailed Hawks were initially exercised by flying 8–10 laps/d (one lap is equivalent to flight from one end of the cage and back to the starting point) and increased to 20 laps/d by the end of their recovery (3–5 wk) before release. Rest time was kept to a minimum (less than 15 sec) between laps. Broad-winged Hawks began with 5–8 laps, which was increased to 15 laps. Barn Owls, Barred Owls and Great Horned Owls began with 4–6 laps, which were increased to 10 laps. The criteria used for increasing a bird's exercise regimen (increasing laps) was determined by the number of laps each bird could fly without rapid respirations (panting) and if the bird was able to make full flights between perches.

Blood-Lactate Level Determination. Once a wk the birds were caught using a large net. Capture was performed immediately after exercise in order to prevent additional flights and to ensure all birds in the same cage had the same number of flights. After capture, the birds were dorsally restrained in weight wrappers that enclosed their body and covered their heads so that the birds remained calm and immobile throughout the subsequent procedure (Engelmann and Marcum 1993, Miller 2000). For this assessment, it is imperative to keep stress levels to a minimum because lactic-acid values can increase due

to stress. Blood samples were drawn from the brachial veins at 2-min postexercise and then at 10-min postexercise. In the time between blood sampling, stress levels were reduced by keeping the birds covered and motionless in a quiet environment. Whole blood (0.02–0.10 ml) was stored on ice for up to 1 hr prior to extracting proteins using twice the volume of 8% perchloric acid. Samples were then centrifuged for 10 min at $2700 \times g$. The supernatant (clear) was removed and kept at 4°C for up to 10 d until performing the lactate assay.

The lactate assay was performed per manufacturer's instructions using the Lactate Diagnostic Kit (Sigma Chemical Co., St. Louis, MO U.S.A.), using a Benchmark Microplate Reader (Bio-Rad Laboratories, Hercules, CA U.S.A.) and Microplate 5.2 data analysis software (Bio-Rad Laboratories, Hercules, CA U.S.A.).

Data Analysis. Data were analyzed by linear regression, and the means of the 2-min and 10-min lactate values were analyzed using a one way Analysis of Variance (ANOVA), followed by Tukey's studentized range test, when appropriate (SAS statistical software, version 5.0, Cary, NC U.S.A.).

RESULTS

The rate of the decrease in blood lactate over the 3–5 wk exercise period for six species of raptors is indicated by the slope of the regression line through each of the averaged lactate values for the 2-min and the 10-min postexercise times (Fig. 1). A negative slope of the regression trend line would suggest an increase in skeletal-muscle fitness.

Four (including orphans) or five (excluding orphans) of the six raptor species examined exhibited a decrease in overall blood-lactate concentrations at one of the time points over the 3–5 wk

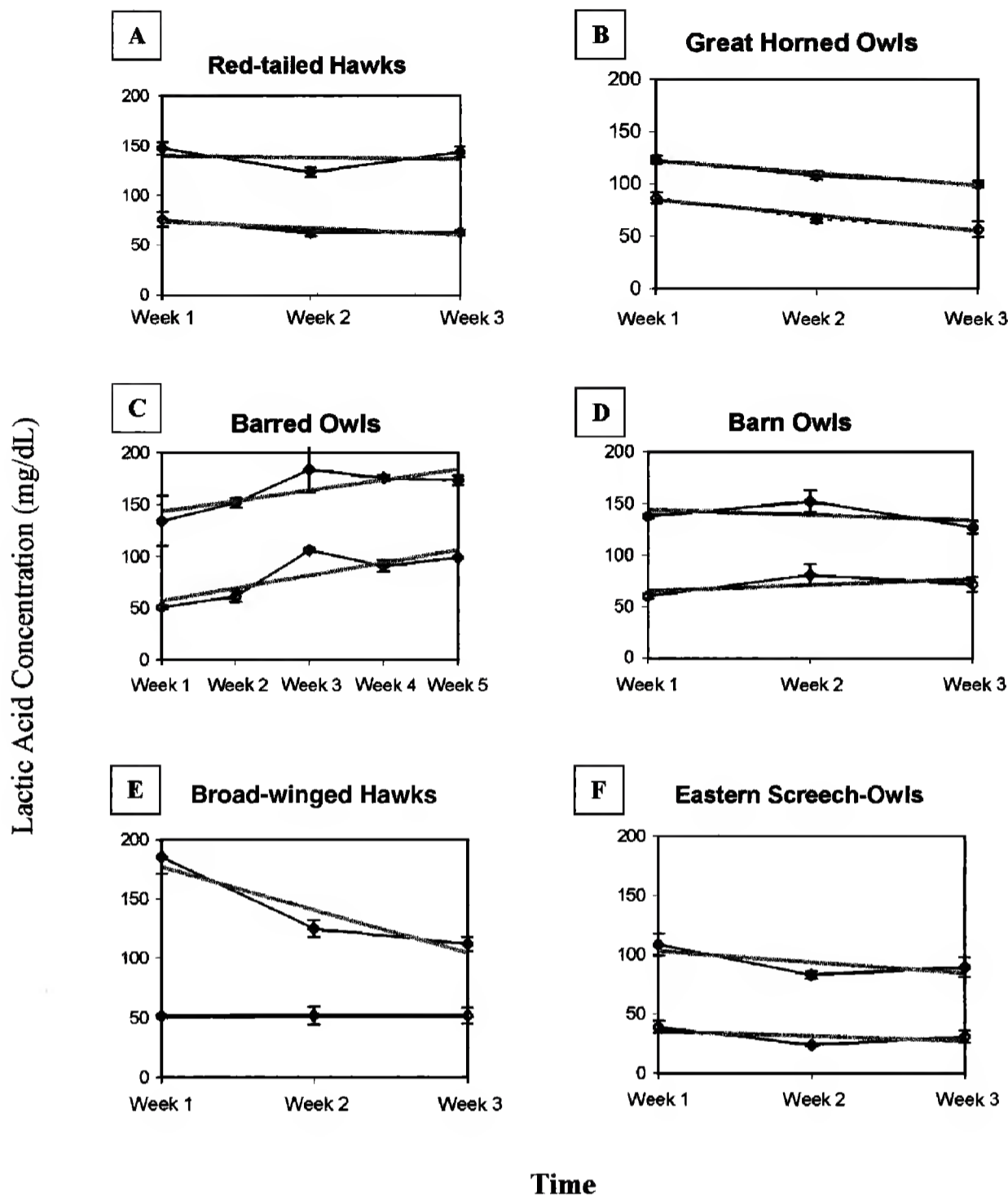


Figure 1. Change in lactate concentrations for six species of raptors over an exercise period (see Methods). Blood-lactate levels were measured postexercise at 2-min (♦) and 10-min (◊) intervals. Data are expressed as the overall blood-lactate levels at the end of each wk, and regression lines (gray solid lines) were calculated to represent the mean change in blood-lactate concentration over time. Panel A—Red-tailed Hawks ($N = 7$). Panel B—Great Horned Owls ($N = 4$). Panel C—Barred Owls ($N = 2$). Panel D—Barn Owls ($N = 3$) regression data exclude one orphan. Panel E—Broad-winged Hawks ($N = 3$) regression data exclude one orphan. Panel F—Eastern Screech-Owls.

exercise period (Table 3). Great Horned Owls had a significant decrease in their lactate values ($P = 0.03$, $F_{23,5} = 4.18$, $N = 4$; Fig. 1B). Eastern Screech-Owls had a decrease in both their lactate values; however, the decrease did not reach significance ($P = 0.17$, $F_{23,5} = 1.91$, $N = 4$; Fig. 1F). Red-tailed Hawks had a decrease in both the 2-min and 10-min values, but again this pattern was not significant ($P = 0.40$, $F_{41,5} = 0.95$, $N = 7$; Fig. 1A). Broad-winged Hawks showed a decrease in their 2-min values, but not in their 10-min values; the decrease

was not significant ($P = 0.25$, $F_{23,5} = 1.50$, $N = 4$; Fig. 1E). However, when the orphaned raptor in this group was removed, the decrease in lactate at 2-min was significant ($P = 0.05$, $F_{17,5} = 3.86$, $N = 3$). There was also a significant interaction between the 2-min and 10-min lactate values ($P = 0.05$, $F_{17,5} = 3.98$, $N = 3$); analysis of the treatment weeks showed that wk 1 and wk 3 were significantly different from each other for the 2-min lactate values ($P < 0.05$), but not for the 10-min lactate values ($P > 0.05$) (Fig. 1E, Table 3). Barn Owls did not

Table 4. Effectiveness of cage flight is influenced by injury type. Linear regression slopes were calculated based on injury type for each species group. One injury or mild injuries include broken talons, tissue damage, mild concussion, or non-blinding eye traumas. Multiple injuries or severe injuries include fractures that are accompanied with other injuries such as emaciation, tissue damage, and eye trauma or eye removal. N/A denotes no birds qualified for this sample group.

RAPTOR SPECIES	ONE INJURY OR MILD INJURIES		MULTIPLE INJURIES OR SEVERE INJURIES		ORPHANED WITH NO INJURIES	
	2-min	10-min	2-min	10-min	2-min	10-min
Red-tailed Hawks	-17.64	-8.28	32.55	7.98	N/A	N/A
<i>N</i>	5	5	2	2		
Great Horned Owls	-12.02	-15.28	N/A	N/A	-1.48	-2.63
<i>N</i>	1	1			3	3
Barred Owls	N/A	N/A	10.25	12.63	N/A	N/A
<i>N</i>			4	4		
Barn Owls	-5.47	-5.74	N/A	N/A	18.75	14.63
<i>N</i>	3	3			1	1
Broad-winged Hawks	-36.66	0.24	N/A	N/A	21.80	13.05
<i>N</i>	3	3			1	1
Eastern Screech-Owls	-9.45	-4.12	N/A	N/A	N/A	N/A
<i>N</i>	4	4				

show a decrease in lactate values over time ($P = 0.46$, $F_{23,5} = 0.82$, $N = 4$). When the orphan in this group was removed, the 2-min lactate value decreased, giving a negative regression slope, but this trend was not significant ($P = 0.58$, $F_{17,5} = 0.55$, $N = 3$; Fig. 1D, Table 3). Barred Owls showed a slight nonsignificant increase in lactate values ($P = 0.05$, $F_{15,7} = 4.01$, $N = 2$; Fig. 1C).

DISCUSSION

Our results indicated that the use of flight cages as a form of rehabilitation exercise may be an adequate method for increasing skeletal-muscle fitness and improving aerobic conditioning of certain species of injured raptors. Of the six raptor species studied, five exhibited a negative linear-regression slope in at least one of the two time points studied (Table 3). The Great Horned Owls showed a statistically significant improvement in lactate recovery with cage flight, indicating that cage flight was sufficient to improve muscle fitness in this species. Red-tailed Hawks and Eastern Screech-Owls showed decreases in both 2-min and 10-min lactate values; however, these trends were not significant. Broad-winged Hawks and Barn Owls (excluding orphans) showed a decrease in the 2-min time lactate values, but these trends were not significant. Further analysis of the Broad-winged Hawks that involved exclusion of the orphaned raptor resulted

in a significant decrease in the lactate values, suggesting that cage flight is useful for the adult injured raptors of this species. These data indicated that use of cage flight may be a valuable method to improve muscle fitness in certain species, such as the Great Horned Owls and Broad-winged Hawks, but may need to be combined with other rehabilitation methods in other species.

Chaplin et al. (1989) proposed guidelines for 2-min and 10-min lactate values postexercise for creance rehabilitation of certain species (e.g., screech-owls, Great Horned Owls, Red-tailed Hawks). The lactate values of the cage-exercised raptors were comparable to the guidelines set by Chaplin (1989); however, the decreases were not as dramatic as seen in this earlier work. There are several reasons that may account for this difference. In flight cages, there was a possibility the raptors did not obtain enough sustained wing flaps, probably coasting to the other perch involving less muscle exertion. Coasting was not observed by the rehabilitators during this study; however, there was a short rest period between flights, which was kept to a minimum (the time for a rehabilitator to walk from one end of the cage to the other; <15 sec). This rest period may account for the decreased effectiveness of the flight cages for these raptors. Future studies should be performed that reduce or eliminate this rest time.

The difference in response of raptors of different species may also be due to differing wing mechanics and hunting behaviors. Great Horned Owls are a perch-and-watch predator and once prey are detected, they pursue their prey by descent or a short-sprint flight. Cage flight may duplicate these hunting flights and could be the reason that the Great Horned Owls responded well to this method of rehabilitation. Other species that are more endurance fliers when hunting, such as Barn Owls, may need longer sustained flights for skeletal-muscle improvement. In this case, cage flight may be a good preliminary exercise method for these species, if it is then followed by other methods such as creance flight.

One confounding factor in this study was the extent of injuries sustained by the raptors (Table 1). The greater number and more complex the injuries sustained, the raptors were less responsive to exercise (Table 4). Raptors with multiple and severe injuries tended to have a positive linear-regression slope for the lactate concentrations over time, as compared to those with one injury or mild injuries, which had negative slopes (Table 4). The differences in injury types may contribute to the variation of responses in the other raptor species, as well as the lack of response to treatment in the Barred Owls, which had severe injuries. In cases of severe injuries, cage flight may be suitable as a preliminary form of exercise. However, it may be necessary to exercise the birds for a longer duration than used in this experiment and use other exercise methods, such as creance flight.

A third, perhaps related, factor was whether the raptor was an orphan. Orphaned raptors did not show an increase in muscle fitness. This may be due to a lack of injuries, and an absence of prior flight experience. The raptor orphans in this study tended to have shallower negative linear lactate regression slopes, or positive slopes as compared to the adult raptors rehabilitated for mild injuries (Table 4). The Broad-winged Hawks demonstrate this pattern. The adult Broad-winged Hawks showed a significant decrease in lactate values, but the orphaned hawk of this species did not show improvement with cage flight. These results are similar to previous research that compared lactate dehydrogenase kinetics between untrained and previously flight-trained Rock Pigeons (*Columba livia*) that were either cage confined, or wing restrained for several wk before retraining (Chaplin et al. 1997). The untrained Rock Pigeons had slow-

er clearance of lactate than did the trained birds, which was similar to what we observed with the orphaned raptors (Table 4). Our results indicated that raptor orphans may need special flight training and for a longer duration than injured adults.

We note that the sizes of the flight cages are important when replicating these findings. The sizes of the flight cages used in this study were determined by the rehabilitation staff at the Carolina Raptor Center based upon previous experience with these raptor species, as well as the amount of available funds. Most of the flight cages were built larger than many current guidelines set forth by the National Wildlife Rehabilitation Association and International Wildlife Rehabilitation Council for unlimited activities (Eastern Screech-Owl, 2.4 m × 2.4 m × 2.4 m; Barn Owl, 3 m × 9 m × 3.6 m; Barred Owl 3 m × 15.2 m × 3.6 m; Great Horned Owl 3 m × 15.2 m × 3.6 m; Broad-winged Hawk, 3 m × 9 m × 3.6 m; and Red-tailed Hawk, 3 m × 15.2 m × 3.6 m; Miller 2000). The fitness criteria used in this study are proposed by Chaplin et al. (1989, 1993) and represent a standard determined using falconry-trained Red-tailed Hawks. This standard may differ for other types of raptors, especially those with very different wing mechanics and flight habits.

ACKNOWLEDGMENTS

We thank the many volunteers at the Carolina Raptor Center who assisted with this research, and Dr. Robert Bierregaard, Dr. Marina Castillo, Dr. Abel Bult-Ito, Pat Rivera, Ron Tavernier, and the two manuscript referees for invaluable comments. This work was supported by a Ronald E. McNair Post-Baccalaureate Achievement Program Scholarship (to D. Greene).

LITERATURE CITED

- CHAPLIN, S.B., L. MUELLER, AND L. DEGERNES. 1989. Physiological assessment of rehabilitated raptors prior to release. *Wildl. J.* 12:7-18.
- , ———, AND ———. 1993. Physiological assessment of flight conditioning of rehabilitated raptors. Pages 167-173 in P.T. Redig [ED.], *Raptor biomedicine*. Univ. Minnesota Press, Minneapolis, MN U.S.A.
- , M.M. MUNSON, AND S.T. KNUTH. 1997. The effect of exercise and restraint on pectoral muscle metabolism in pigeons. *J. Comp. Physiol.* 167:197-203.
- ENGELMANN, M. AND P. MARCUM. 1993. *Raptor rehabilitation: a manual of guidelines offered by the Carolina Raptor Center*. Carolina Raptor Center, Charlotte, NC U.S.A.
- MILLER, E.A. (ED.). 2000. *Minimum standards for wildlife rehabilitation*, 3rd Ed. National Wildlife Rehabilitators Association, St. Cloud, MN U.S.A.

- MUELLER, L.R. AND S.B. CHAPLIN. 1990. Flight conditioning in raptors; a physiological test of aerobic fitness. *Wildl.Rehab.* 8:135-141.
- PATTON, K.T. AND W.C. CRAWFORD, JR. 1985. Stress in captive birds of prey. *Wildl. Rehab.* 4:43-48.
- PERSSON, S.G.B. 1983. Evaluation of exercise tolerance and fitness in the performance horse. Pages 441-457 in D.H. Snow, S.G.B. Persson, and J.R. Rose [EDS.], Equine exercise physiology. Burlington Press, Cambridge, U.K.
- READ, N. 1990. Species specific cage design for raptors. *Wildl. Rehab.* 8:73-80.

Received 1 November 2002; accepted 13 February 2004
Associate Editor: Ian G. Warkentin

MODELING HABITAT USE AND DISTRIBUTION OF HEN HARRIERS (*CIRCUS CYANEUS*) AND MONTAGU'S HARRIER (*CIRCUS PYGARGUS*) IN A MOUNTAINOUS AREA IN GALICIA, NORTHWESTERN SPAIN

LUIS TAPIA¹ AND JESÚS DOMÍNGUEZ

Dpto. de Biología Animal, Facultade de Biología, Universidad de Santiago de Compostela, Campus sur, s/n, 15782 Galicia, Spain

LUIS RODRÍGUEZ

Dpto. de Edafología e Química agrícola, Facultade de Biología, Universidad de Santiago de Compostela, Campus sur, s/n, 15782 Galicia, Spain

ABSTRACT.—To evaluate the effect of habitat characteristics on the sympatric populations of Hen Harriers (*Circus cyaneus*) and Montagu's Harriers (*Circus pygargus*), we have developed predictive models (logistic regression) for the presence/absence and distribution of harriers in the Site of Community Importance Baixa-Limia, northwestern Spain. We have used habitat and topographical variables measured on digital 1:50 000-scale cartography. We have developed spatial prediction on suitable habitat availability for harriers by means of Geographical Information System Analysis of 2 × 2 km plots. The final models explained 11% of the variance for Hen Harrier, 18% of the variance for the Montagu's Harrier, and 12% of the variance for both species simultaneously. Altitude was a variable that influenced the presence of both harrier species, which were more common over 800 m. The presence of Montagu's Harrier in a plot was positively associated with the presence of gradual relief of Atlantic heathland. The most important threats to harrier populations are human infrastructures (e.g., roads, tracks), proliferation of human activities such as afforestation and intense deliberate wild-fires that change the habitat conditions for both species.

KEY WORDS: *Hen Harrier, Circus cyaneus; Montagu's Harrier, Circus pygargus; habitat use, modeling, Spain.*

MODELIZACIÓN DEL USO DEL HÁBITAT Y DISTRIBUCIÓN DEL AGUILUCHO PÁLIDO (*CIRCUS CYANEUS*) Y AGUILUCHO CENIZO (*CIRCUS PYGARGUS*) EN UN ÁREA MONTAÑOSA DE GALICIA (NO ESPAÑA)

RESUMEN.—Con el objetivo de evaluar el efecto de las características del hábitat sobre poblaciones simpátricas de aguilucho pálido (*Circus cyaneus*) y aguilucho cenizo (*Circus pygargus*), desarrollamos modelos estadísticos predictivos (Análisis de Regresión Logística) para la presencia/ausencia y distribución de los aguiluchos en el LIC (Lugar de Interés Comunitario) Baixa-Limia (NO España). Usamos variables ambientales medidas sobre cartografía digital a escala 1:50 000, utilizando un Sistema de Información Geográfica con la retícula de 2 × 2 km. Los modelos finales explicaron un 11% de la varianza para el aguilucho pálido, un 18% para el aguilucho cenizo y un 12% para ambas especies simultáneamente. La altitud fue un factor que influyó en la presencia de ambas especies, siempre por encima de 800 m. La presencia de aguilucho cenizo en una cuadrícula se relacionó positivamente con la presencia de áreas con relieve suave de brezal atlántico. Las amenazas más importantes son infraestructuras como carreteras y pistas de tierra, repoblaciones y grandes incendios forestales intencionados, modificadores de las condiciones del hábitat de ambas especies.

[Traducción de los autores]

Determination of the variables that influence the distribution of species has been one of the

most important objectives of ecology (Cody 1985, Wiens 1989). Studies of habitat selection have traditionally analyzed the relations of one species relative to the characteristics of its habitat; often leading to the development of predictive models

¹ E-mail address: baltapia@usc.es

(Morrison et al. 1998). These models are particularly important in efforts to preserve threatened species, as for example in the case of some Iberian raptor species (e.g., Donázar et al. 1993, Gil-Sánchez et al. 1996, Bustamante 1997, Sánchez-Zapata and Calvo 1999), even though they are not exempt from severe limitations (Fielding and Haworth 1995, Beutel et al. 1999, Seoane and Bustamante 2001). Raptors are usually highly selective with regard to their habitat, especially regarding the availability of suitable areas for breeding and hunting (Janes 1985).

The spatial scale involved is important to understanding the implications and limitations of predictive models (e.g., Litvaitis et al. 1994, Pribil and Picman 1997, Rotenberry and Knick 1999, Mitchell et al. 2001). In this respect, the models on scales similar to or greater than the home range seem to establish relations amongst raptors with regard to the selection of macrohabitat and associations with ecosystem mosaics (Sánchez-Zapata and Calvo 1999, Rico-Alcázar et al. 2001).

The Hen Harrier (*Circus cyaneus*) and the Montagu's Harrier (*Circus pygargus*) have declining populations in Europe (Tucker and Evans 1997). On the Iberian peninsula, these harriers usually use cereal crop lands as nesting habitat (Ferrero 1996), even though in the northwestern part of the peninsula they usually breed in areas of natural vegetation (Pinilla et al. 1994, Vázquez-Pumariño 1995, Ferrero 1996). Studies of habitat selection and predictive modeling for these species are scarce, both for the European continent and in the Iberian peninsula (Salamolard 1997, Martínez et al. 1999, Madders 2000). In Galicia (northwestern Spain), both harrier species are sympatric, occurring in an area dominated by Atlantic-heathland shrubs.

The objective of the present study was to establish models of habitat selection using the information obtained from an atlas of nesting birds. The atlases of the distribution of species are very limited with respect to the information they provide (Donald and Fuller 1998, Sutherland 2000), but they may be used as a very important source of information to create predictive models of distribution for different species of vertebrates (e.g., Osborne and Tigar 1992, Jaber and Guisan 2001, Rojas et al. 2001). These models will become a tool which will contribute to the management of a protected area relating to two high priority species included in Annex I of the Birds Directive 79/409/79 European Economic Community. Annex I lists

species of birds in Europe which are of priority for habitat conservation (Tucker and Evans 1997).

STUDY AREA AND METHODS

The study area is 40 000 ha, the majority of which (34 627 ha) is the Site of Community Importance (SCI) Baixa Limia. It extends along the southwestern sierras of the province of Ourense, bordering the National Portuguese Park of Peneda-Gêres (Fig. 1). Both protected areas, the Spanish and the Portuguese, cover in total an area of 106 627 ha.

It is a mountain range of medium altitude, with summits of up to 1500 m, comprised predominantly of granite rocks. Currently, human population in the area is quite low, even though the landscape has been intensely affected by human actions. From the climatic point of view, this area has a temperate sub-Mediterranean oceanic climate of 8–12°C, with an annual precipitation of 1200–1600 mm, and a significant water shortage in the summer (Martínez-Cortizas and Pérez-Alberti 1999). The most common types of vegetation are the shrub communities (*Ulex* sp., *Chamaespartium tridentatum*, *Erica* sp., *Genista* sp., and *Cytisus* sp.), which constitute the greatest percentage of vegetation. Woods are very fragmented, and are dominated by oaks (*Quercus robur*, *Q. pyrenaica*) and pines (*Pinus pinaster*, *P. sylvestris*). All plant communities in the study area are impacted by frequent deliberate fires, sometimes affecting large areas.

The harrier's distribution in the study area was obtained from field work carried out in the spring seasons, 1997–2000. This work consisted of systematic surveys throughout the study area, although the entire study area was only covered in spring 2000 considering the sampling effort necessary for the detection of harrier species (Pinilla and Arroyo 1995). Evidence of occupancy by a nesting harrier included: a nest containing eggs or young, adults seen carrying food, and hearing the begging calls of young birds (Bibby et al. 1992). With the help of Global Positioning System (GPS), all the observations were located in the corresponding 1 × 1 km square (maps 1: 25 000). This sampling was carried out with the aim of completing an atlas for breeding harriers.

Harrier's presence for any breeding category was the dependent variable used in the analysis (Hagemeijer and Blair 1997). Breeding categories included: possible breeding (harriers observed in potential nesting habitat), probable nesting (pair observed in suitable nesting habitat, courtship, display, or nest building) and confirmed breeding (nest contained eggs or young) (Hagemeijer and Blair 1997). Presence was obtained from the final distribution atlas, derived from cumulative observed data for the 1997–2000 period. Atlas data indicated that the local Montagu's Harrier population in Baixa-Limia was 15–20 pairs, and the Hen Harrier population was 8–10 pairs.

For the analysis of habitat selection a 2 × 2 km grid was used, integrating the information obtained in the 1 × 1 km squares. The 2 × 2 km squares which had less than 50% of their surfaces within the limits of the SCI or more than 50% in Portugal were discounted. For analysis we used the 2 × 2 km grid, due to the low proportion of grid squares in which harriers were present based on a 1 × 1 km grid, and also because the cartography used



Figure 1. Study site (*Baixa Limia*) in Galicia (northwestern Iberian peninsula).

lost resolution at small scales (Sánchez-Zapata 1999, Zuberogitia 2002).

The independent variables were selected because they represented different uses of the land, degree of humanization, topographic irregularity, and habitat heterogeneity (Table 1), and values for each variable were assumed for each 2×2 plot studied. The information relating to the different environmental variables was tak-

en from 1:50 000 digital cartography via a Geographic Information System (GIS-ArcView 3.1, Environmental Systems Research Institute, Inc., Redlands, CA U.S.A.). The digital cartography used had a resolution of 250×250 m.

Continuous variables (i.e., slope and altitude) were obtained from analysis of the variable of each square using a digital elevation model with a resolution of $250 \times$

Table 1. Independent variables included in the logistic regression for the habitat models of Hen Harrier and Montagu's Harrier in the Site of Community Importance Baixa-Limia.

LABEL	DESCRIPTION OF THE VARIABLE
No. settlements	Number of human settlements
Area of settlements	Area of human settlements
Road length (m)	Length of paved roads
Min. altitude (m)	Minimum altitude
Max. altitude (m)	Maximum altitude
Max.-min. altitude (m)	Maximum altitude-minimum altitude
Mean altitude (m)	Average altitude
Min. slope (grades)	Minimum slope
Max. slope (grades)	Maximum slope
Max.-min. slope (grades)	Maximum slope-minimum slope
Mean slope (grades)	Average slope
Scrub-pasture area (km ²)	Area of scrubland and pastureland
Forest area (km ²)	Area of forests
Dam area (km ²)	Area of dams
Scrub-forest edge (m)	Meters of edge between scrubland-forests
Scrub-dam edge (m)	Meters of edge between scrubland-dam
Forest-dam edge (m)	Meters of edge between forest-dam

250 m. The remaining variables were obtained directly with GIS using vectorial data. Scrubland and pasture surfaces are often intermixed. They were treated as one cover type because they could not be distinguished at the spatial resolution used. All forest types were also treated as the same variable independent of their tree species composition. Forests and scrubland-pastures represented close to 90% of the total study area.

A Mann-Whitney *U*-test was used to establish which variables were significantly different between plots in which both species (independently) were present or absent. Those variables that showed significant differences were included in the stepwise-logistic regression analysis (Jovell 1995). The significance of the variables included in the final regression model was determined by the Wald test (Jovell 1995). The level of significance used was $P < 0.05$. We used SPSS package (SPSS 11, McGraw-Hill, Madrid, Spain) for statistical analysis.

RESULTS

Within the study area, the Hen Harrier was detected in 62 1-km² plots of 397 (15.6%) and in 32 4-km² squares of 93 (34.4%). With regard to the Montagu's Harrier, its presence was detected in 123 1-km² plots (31%), and in 60 4-km² plots of 2 × 2 km (64%). Both species were detected in 31 1-km² (7.8%), and in 27 4-km² plots (29%).

At the 4-km² plot scale, the areas occupied by the Hen Harrier differed from the unoccupied ones in that the former had fewer human settlements. Hen Harrier plots were located at higher altitudes and on more gradual slopes than unoccupied squares (Table 2). For the Montagu's Har-

rier, occupied plots had a greater extent of scrubland and were located significantly higher than unoccupied squares (Table 3), although they were rarely present above 1000 m above sea level.

Considering both species simultaneously, the areas occupied differed from the unoccupied ones in that the former had fewer human settlements. Also, occupied plots were located at greater altitude and more gradual slopes than the unoccupied squares (Table 4).

The analysis of logistic regression only included the variables of minimum altitude for both species and scrubland and pastureland area for the Montagu's Harrier; both related positively to occupancy. For both species simultaneously, the model included minimum altitude related positively to occupancy (Table 5).

The final model developed for the Hen Harrier was: $\text{occupancy} = 1/1 + e^{2.812 - 0.003(\text{min altitude})}$, and explained 11% of the variance. The overall correct classification was 65.6%. The final model developed for the Montagu's Harrier was: $\text{occupancy} = 1/1 + e^{2.818 - 4.96 \times 10^{-7}(\text{Scrub and pasture area}) - 0.003(\text{min altitude})}$, explained 18% of the variance. The overall correct classification was 64.5%.

The final model developed for both species simultaneously was: $\text{occupancy} = 1/1 + e^{3.359 - 0.003(\text{min altitude})}$, explained 12% of the variance. The overall correct classification was 71%.

Table 2. Comparison of mean values of variables, using Mann-Whitney tests, in 2×2 km plots occupied and unoccupied by Hen Harrier in the Site of Community Importance Baixa-Limia (Mean \pm SD).

LABEL	OCCUPIED	UNOCCUPIED	U	P
	SQUARES 2×2 km (N = 32)	SQUARES 2×2 km (N = 61)		
No. settlements	0.1563 \pm 0.5741	0.4262 \pm 0.8054	782.0	0.031*
Area of settlements	6073 \pm 26 763	24 440 \pm 52 130	774.5	0.026*
Road length (m)	374 \pm 737	887 \pm 1314	812.0	0.131
Min. altitude (m)	831 \pm 176	695 \pm 244	606.0	0.003**
Max. altitude (m)	1165 \pm 131	1077 \pm 228	707.0	0.030*
Max.-min. altitude (m)	334 \pm 120	381 \pm 138	732.0	0.048*
Mean altitude (m)	1009 \pm 151	889 \pm 243	651.0	0.009**
Min. slope (grades)	0.24 \pm 0.17	0.31 \pm 0.23	826.5	0.227
Max. slope (grades)	32.36 \pm 7.47	35.27 \pm 9.94	756.5	0.076
Max.-min. slope (grades)	33.11 \pm 7.38	34.95 \pm 9.9	768.0	0.093
Mean slope (grades)	9.47 \pm 3.31	10.93 \pm 3.67	681.5	0.017*
Scrub-pasture area (km ²)	2.94 \pm 0.92	2.63 \pm 0.95	785.5	0.131
Forest area (km ²)	0.75 \pm 0.80	0.92 \pm 0.87	876.0	0.419
Dam area (km ²)	0.03 \pm 0.13	0.12 \pm 0.42	909.0	0.314
Scrub-forest edge (m)	10 978 \pm 7518	11 731 \pm 9073	953.5	0.856
Scrub-dam edge (m)	110 \pm 538	488 \pm 1496	919.0	0.369
Forest-dam edge (m)	37 \pm 212	123 \pm 447	895.0	0.178

* Significantly different at $P < 0.05$.** Significantly different at $P < 0.01$.Table 3. Comparison of mean values of variables, using Mann-Whitney tests, in 2×2 km plots occupied and unoccupied by Montagu's Harrier in the Site of Community Importance Baixa-Limia (Mean \pm SD).

LABEL	OCCUPIED	UNOCCUPIED	U	P
	SQUARES 2×2 (N = 60)	SQUARES 2×2 (N = 33)		
No. settlements	0.2667 \pm 0.7334	0.4545 \pm 0.7538	828.5	0.075
Area of settlements	14 055 \pm 39 823	25 510 \pm 54 765	827.0	0.074
Road length (m)	571 \pm 1056	964 \pm 1334	844.0	0.181
Min. altitude (m)	793 \pm 212	650 \pm 238	654.0	0.007**
Max. altitude (m)	1145 \pm 176	1039 \pm 234	746.0	0.050*
Max.-min. altitude (m)	352 \pm 134	389 \pm 130	820.0	0.172
Mean altitude (m)	978 \pm 198	844 \pm 241	683.0	0.014*
Min. slope (grades)	0.28 \pm 0.22	0.31 \pm 0.21	880.5	0.379
Max. slope (grades)	33.33 \pm 10.04	35.97 \pm 7.35	799.0	0.125
Max.-min. slope (grades)	33.05 \pm 9.98	35.66 \pm 7.33	802.5	0.132
Mean slope (grades)	10.02 \pm 3.70	11.17 \pm 3.34	803.5	0.134
Scrub-pasture area (km ²)	2.89 \pm 0.90	2.46 \pm 0.99	701.0	0.020*
Forest area (km ²)	0.79 \pm 0.79	1.0 \pm 0.94	836.0	0.216
Dam area (km ²)	0.08 \pm 0.33	0.11 \pm 0.4	969.0	0.754
Scrub-forest edge (m)	11 002 \pm 8227	12 326 \pm 9139	908.0	0.510
Scrub-dam edge (m)	296 \pm 1122	471 \pm 1494	951.0	0.547
Forest-dam edge (m)	69 \pm 271	139 \pm 534	979.0	0.856

* Significantly different at $P < 0.05$.** Significantly different at $P < 0.01$.

Table 4. Comparison of mean values of variables, using Mann-Whitney test, in 2×2 km plots occupied and unoccupied by both species simultaneously in the Site of Community Importance Baixa-Limia (Mean \pm SD).

LABEL	OCCUPIED	UNOCCUPIED	U	P
	SQUARES 2×2 (N = 27)	SQUARES 2×2 (N = 66)		
No. settlements	0.1481 \pm 0.6015	0.4091 \pm 0.7840	706.0	0.032*
Area of settlements	7074 \pm 29 103	22 639 \pm 50 485	703.5	0.030*
Road length (m)	432 \pm 790	825 \pm 1282	785.0	0.307
Min. altitude (m)	847 \pm 178	699 \pm 237	515.0	0.001**
Max. altitude (m)	1164 \pm 139	1084 \pm 222	660.0	0.051
Max.-min. altitude (m)	317 \pm 118	384 \pm 135	581.0	0.009**
Mean altitude (m)	1016 \pm 155	895 \pm 236	582.0	0.009**
Min. slope (grades)	0.22 \pm 0.16	0.32 \pm 0.23	664.5	0.055
Max. slope (grades)	31.19 \pm 7.21	35.53 \pm 9.7	600.5	0.014*
Max.-min. slope (grades)	30.97 \pm 7.15	35.20 \pm 9.66	613.0	0.019*
Mean slope (grades)	9 \pm 3.25	11.01 \pm 3.60	531.5	0.002**
Scrub-pasture area (km ²)	2.74 \pm 0.95	2.67 \pm 0.96	751.5	0.238
Forest area (km ²)	0.80 \pm 0.85	0.89 \pm 0.85	825.0	0.576
Dam area (km ²)	0.04 \pm 0.15	0.11 \pm 0.41	849.0	0.509
Scrub-forest edge (m)	11 508 \pm 7863	11 457 \pm 8854	863.5	0.816
Scrub-dam edge (m)	130 \pm 585	451 \pm 1443	856.5	0.569
Forest-dam edge (m)	44 \pm 230	113 \pm 431	830.0	0.288

* Significantly different at $P < 0.05$.

** Significantly different at $P < 0.01$.

DISCUSSION

The Hen Harrier had a strong tendency to occupy relatively-level areas in higher altitude of the study area, dominated by Atlantic-heathland vegetation with scarce human presence. These harriers did not have a tendency to occupy heterogeneous habitats at the scale examined. At finer scales, individuals may be influenced by the structure of shrub formations within their home ranges, when exploiting different trophic resources (Preston 1990, Madders 2000).

The Montagu's Harrier seemed to show a preference for natural shrub formations (e.g., *Erica* sp., *Ulex* sp., *Cytisus* sp. and pasture), just as in other areas of the northwestern Iberian peninsula (Vázquez-Pumariño 1995), where there was a lack of large areas of cereal cultivation. Our data also indicated a tendency for Montagu's Harriers to occur in zones of higher altitude.

For both species simultaneously, the final logistic model included only one variable, minimum altitude. This result suggests that preserving the natural Atlantic-heathland vegetation above 800 m may aid in the conservation of the harrier populations of the Baixa-Limia, as well as those in other mountain range areas in Galicia. A greater part of

the harrier population in northwestern Spain depends on this habitat, which together with the decline of many European populations (Etheridge and Hustings 1997, Krogulec 1997), justifies the need for habitat management to improve species viability.

The frequency of deliberate small fires in the heathland areas studied, particularly during winter, may favor the creation of a mosaic of scrub types, with bordering areas which might provide suitable habitat for these and other raptors (Dodd 1988, Kochert et al. 1999). On the other hand, the proliferation of intense fires, particularly in spring and summer, may endanger nesting and cause declines of some prey species (Camprodon and Plana 2001).

The abundant presence of livestock grazing in some of these mountain zones reduces the development of shrub vegetation, potentially influencing the abundance of some prey and their vulnerability to capture by raptors (Kochert et al. 1988, Thirgood et al. 2002). The maintenance of traditional agricultural practices such as extensive grazing, and heterogeneous cultivation, are key to the maintenance of the fauna in some European habitats (Tucker and Evans 1997).

Table 5. Logistic regression models for the probability of finding Montagu's Harrier, Hen Harrier and both species simultaneously in the Site of Community Importance Baixa-Limia.

	B	SE	WALD	P
Hen Harrier				
Intercept	-2.812	0.888		
Min. altitude	0.003	0.001	6.749	0.009
Montagu's Harrier				
Intercept	-2.818	1.054		
Scrub-pasture area	4.96×10^{-7}	0.000	4.174	0.041
Min. altitude	0.003	0.001	7.391	0.007
Both species simultaneously				
Intercept	-3.359	0.981		
Min. altitude	0.003	0.001	7.264	0.007

The most significant threats for the mountainous habitats observed in the study area are the proliferation of roads and the massive afforestation of zones of scrub-pasture land. These changes result in the progressive destruction of suitable hunting and nesting habitats for harriers and other species of raptors adapted to open habitats (Tucker and Evans 1997, Petty 1998, Madders 2000). To conserve harriers effectively, we recommend restrictions on the proliferation of roads and managing to improve scrubland habitats.

ACKNOWLEDGMENTS

This study was financed with funds from the Consellería de Medio Ambiente and the project PGIDT99 PXI20002B (Xunta de Galicia). We express our gratitude to Manuel Romeu, Xusto Calvo, Marta Arenas, and Sara Sánchez for their collaboration in the field work; to Enrique Rego, Javier Seoane, and Javier Bustamante for their help with the statistical analysis. Garry Bushnell, Beatriz López and Petra Kidd translated the manuscript into English. We thank Beatriz Arroyo, Juan José Negro, and Jim Bednarz for helpful comments and suggestions on the manuscript.

LITERATURE CITED

- BEUTEL, T.S., R.J. BEETON, AND G.S. BAXTER. 1999. Building better wildlife-habitat models. *Ecography* 22:219–223.
- BIBBY, C.J., N.D. BURGESS, AND D.A. HILL. 1992. Bird census techniques. Academic Press, London, U.K.
- BUSTAMANTE, J. 1997. Predictive models for Lesser Kestrel (*Falco naumanni*) distribution, abundance and extinction in southern Spain. *Biol. Conserv.* 80:153–160.
- CAMPRODÓN, J. AND E. PLANA (EDS.). 2001. Conservación de la biodiversidad y gestión forestal. Su aplicación en la fauna vertebrada. Edicions de la Universitat de Barcelona, Barcelona, Spain.
- CODY, M.L. 1985. Habitat selection in birds. Academic Press, Orlando, FL U.S.A.
- DODD, N.N. 1988. Fire management and southwestern raptors. Pages 341–347 in Proceedings of the southwest raptor management symposium and workshop. Natl. Wildl. Fed., Washington, DC U.S.A.
- DONALD, P.F. AND R.J. FULLER. 1998. Ornithological atlas data: a review of uses and limitations. *Bird Study* 45: 129–145.
- DONÁZAR, J.A., F. HIRALDO, AND J. BUSTAMANTE. 1993. Factors influencing nest site selection, breeding density, and breeding success in the bearded vulture (*Gypaetus barbatus*). *J. Appl. Ecol.* 30:504–514.
- ETHERIDGE, B. AND F. HUSTINGS. 1997. *Circus cyaneus*. Pages 148–149 in W.J.M. Hagemeijer and M.J. Blair [EDS.], The EBCC atlas of European breeding birds. their distribution and abundance. T. & A.D. Poyser, London, U.K.
- FERRERO, J.J. 1996. La población ibérica de Aguilucho Cenizo (*Circus pygargus*). *Alytes* 7:539–560.
- FIELDING, A.H. AND P.F. HAWORTH. 1995. Testing the generality of bird-habitat models. *Conserv. Biol.* 9:1466–1481.
- GIL-SÁNCHEZ, J.M., F. MOLINO GARRIDO, AND S. VALENZUELA. 1996. Selección de hábitat de nidificación por el Águila perdicera (*Hieraaetus fasciatus*) en Granada (SE de España). *Ardeola* 43:189–197.
- HAGEMEIJER, W.J.M. AND M.J. BLAIR (EDS.). 1997. The EBCC atlas of European breeding birds: their distribution and abundance. T. & A.D. Poyser, London, U.K.
- JABER, C. AND A. GUISAN. 2001. Modelling the distribution of bats in relation landscape structure in a temperate mountain environment. *J. Appl. Ecol.* 38:1169–1181
- JANES, S.W. 1985. Habitat selection in raptorial birds. Pages 159–188 in M.L. Cody [Ed.], Habitat selection in birds. Academic Press, San Diego, CA U.S.A.

- JOVELL, A.J. 1995. Análisis de regresión logística. Centro de investigaciones sociológicas, Madrid, Spain.
- KOCHERT, M.N., B.A. MILLSAP, AND K. STEENHOF. 1988. Effects of livestock grazing on raptors with emphasis on southwestern U.S. Pages 325–333 in Proceedings of the southwest raptor management symposium and workshop. Natl. Wildl. Fed., Washington, DC U.S.A.
- , K. STEENHOF, L.B. CARPENTER, AND J.M. MARZLUFF. 1999. Effects of fire on Golden Eagle territory occupancy and reproductive success. *J. Wildl. Manage.* 63:773–780.
- KROGULEC, J. 1997. *Circus pygargus*. Pages 150–151 in W.J.M. Hagemeijer and M.J. Blair [EDS.], The EBCC atlas of European breeding birds: their distribution and abundance. T. & A.D. Poyser, London, U.K.
- LITVAITIS, J.A., K. TITUS, AND E.M. ANDERSON. 1994. Measuring vertebrate use of terrestrial habitats and foods. Pages 254–271 in T.A. Bookhout [ED.], Research and management techniques for wildlife and habitats. The Wildlife Society, Bethesda, MD U.S.A.
- MADDERS, M. 2000. Habitat selection and foraging success of Hen Harriers *Circus cyaneus* in west Scotland. *Bird Study* 47:32–40.
- MARTÍNEZ CORTIZAS, A. AND A. PÉREZ ALBERTI. 1999. Atlas bioclimático de Galicia. Xunta de Galicia, Santiago de Compostela, Spain.
- MARTÍNEZ, J., A.G. LÓPEZ, F. FALCO, A. CAMPO, AND A. DE LA VEGA. 1999. Hábitat de caza y nidificación del Aguilucho cenizo (*Circus pygargus*) en el Parque natural de la Mata-Torreveja (Alicante, SE de España): efectos de la estructura de la vegetación y de la densidad de presas. *Ardeola* 46:205–212.
- MITCHELL, M.S., R.A. LANCIA, AND J.A. GERWIN. 2001. Using landscape-level data to predict the distribution of birds on a managed forest: effects of scale. *Ecol. Appl.* 11:1692–1708.
- MORRISON, M.L., B.G. MARCOT, AND R.W. MANNAN. 1998. Wildlife-habitat relationships: concepts and applications. Univ. Wisconsin Press, Madison, WI U.S.A.
- OSBORNE, P.E. AND B.J. TIGAR. 1992. Interpreting bird atlas data using models: an example from Lesotho, southern Africa. *J. Appl. Ecol.* 29:55–62.
- PARDO, A. AND M.A. RUTZ. 2002. SPSS 11. Guía para el análisis de datos. McGraw-Hill, Madrid, Spain.
- PETTY, S.J. 1998. Ecology and conservation of raptors in forests. Bulletin 118. The Stationery Office, London, U.K.
- PINILLA, J., R. ARAMBARI, AND A. RODRÍGUEZ. 1994. Distribución actual y estima poblacional del Aguilucho Pálido (*Circus cyaneus*) en España. *Ardeola* 41:177–181.
- AND B. ARROYO. 1995. Consideraciones metodológicas en la realización de censos de Aguilucho cenizo (*Circus pygargus*). Pages 561–567 in J.J. Ferrero [ED.], Aguiluchos Ibéricos, *Alytes*. ADENEX, Extremadura, Spain.
- PRESTON, C. 1990. Distribution of raptor foraging in relation to prey biomass and habitat structure. *Condor* 92:107–112.
- PRIBIL, S. AND J. PICMAN. 1997. The importance of using the proper methodology and the spatial scale in the study of habitat selection by birds. *Can. J. Zool.* 75:1835–1844.
- RICO-ALCÁZAR, L., J.A. MARTÍNEZ, S. MORÁN, J.R. NAVARRO, AND D. RICO. 2001. Preferencias de hábitat del Águila-azor perdicera (*Hieraaetus fasciatus*) en Alicante (E de España) a dos escalas espaciales. *Ardeola* 48:55–62.
- ROJAS, A.B., I. COTILLA, R. REAL, AND L.J. PALOMO. 2001. Determinación de las áreas probables de distribución de los mamíferos terrestres en la provincia de Málaga. *Galemys* 13:217–229.
- ROTBERRY, J.T. AND S.T. KNICK. 1999. Multiscale habitat associations of the Sage Sparrow: implications for conservation biology. *Stud. Avian Biol.* 19:95–103.
- SALAMOLARD, M. 1997. Utilisation de l'espace par le Busard cendré *Circus pygargus*. *Alauda* 65:307–320.
- SÁNCHEZ-ZAPATA, J. AND J.F. CALVO. 1999. Raptor distribution in relation to landscape composition in semi-arid Mediterranean habitats. *J. Appl. Ecol.* 36:254–262.
- SEOANE, J. AND J. BUSTAMANTE. 2001. Modelos predictivos de la distribución de especies: una revisión de sus limitaciones. *Ecología* 15:9–21.
- SUTHERLAND, W.J. 2000. The conservation handbook. Research, management and policy. Blackwell Science, London, U.K.
- THIRGOOD, J.S., S.M. REDPATH, S. CAMPBELL, AND A. SMITH. 2002. Do habitat characteristics influence predation on Red Grouse? *J. Appl. Ecol.* 39:217–225.
- TUCKER, G.M. AND M.I. EVANS. 1997. Habitats for birds in Europe: a conservation strategy for the wider environment. BirdLife International, Cambridge, U.K.
- VÁZQUEZ-PUMARIÑO, X. 1995. Introducción a la situación de las poblaciones nidificantes del Género *Circus* en la provincia de Lugo. Pages 161–167 in J.J. Ferrero [ED.], Aguiluchos Ibéricos, *Alytes*. ADENEX, Extremadura, Spain.
- WIENS, J.A. 1989. The ecology of bird communities. Cambridge Univ. Press, Cambridge, U.K.
- ZUBEROGOITIA, I. 2002. Ecoetología de las rapaces nocturnas de Bizkaia. Tesis Doctoral, Universidad del País Vasco, Leioa, Spain.

Received 1 November 2002; accepted 22 December 2003
Associate Editor: Juan José Negro

CURRENT STATUS OF THE OSPREY IN THE CAPE VERDE ISLANDS

LUÍS PALMA¹ AND JOÃO FERREIRA

CCMAR, Universidade do Algarve, Campus de Gambelas, 8005-139 Faro, Portugal

ROGÉRIO CANGARATO

Centro de Estudos de Avifauna Ibérica, Rua do Raimundo 119, Apart. 535, 7000-506 Évora, Portugal

PEDRO VAZ PINTO

Centro de Estudos e Investigação Científica, Universidade Católica de Angola, R. Nossa Senhora da Muxima n° 29, C.P. 2054, Luanda, Angola

ABSTRACT.—In 1998 and 1999, we carried out a systematic survey of the Osprey (*Pandion haliaetus*) in the Cape Verde Islands, to evaluate its population and conservation status. Some poorly surveyed areas were revisited in the summer of 2001 to complete our status assessment. We found an estimated 72–81 pairs on the archipelago, of which 94% were concentrated in the northern *Barlavento* (windward) islands group. In this area the species is common and seems to be recovering from a presumed decline, probably caused by a long-term overharvesting of eggs and nestlings by humans during past decades. On the contrary, in the southern *Sotavento* (leeward) islands the species is currently scarce, seemingly still on the decline and already extirpated in the southwesternmost islands. The high percentage of abandoned near-shore nests in the eastern “flat” islands is probably associated with the increasing tourism activities.

KEY WORDS: *Osprey*; *Pandion haliaetus*; *Cape Verde Islands*; *survey*; *status*.

ESTADO ACTUAL DEL ÁGUILA PESCADORA *PANDION HALIAETUS* EN LAS ISLAS DE CABO VERDE

RESUMEN.—Durante el año 1998 y la primavera de 1999 se hizo una prospección sistemática del águila pescadora (*Pandion haliaetus*) en las islas de Cabo Verde con la intención de actualizar la información sobre su estado poblacional y de conservación. Algunas áreas peor prospectadas fueran visitadas en el verano de 2001 para confirmar datos anteriores. Se obtuvo como estimación más probable el número de 72–81 parejas reproductoras en todo el archipiélago, largamente (94%) concentradas en el grupo de islas septentrionales del *Barlavento*. En este área, la especie es bastante común y parece estar recuperándose de un presunto declive durante las décadas pasadas, como resultado probable de un continuo expolio de huevos y pollos para la alimentación humana. Al contrario, en las islas del grupo sureño del *Sotavento*, la especie es actualmente muy escasa y sigue aparentemente en declive y incluso ya extinguida en las islas del extremo suroccidental. El incremento del turismo costero constituye una amenaza adicional para los núcleos poblacionales de las islas “llanas” orientales al echar la especie de sus sitios vulnerables de nidificación costera, como lo indica el alto porcentaje de nidos abandonados a lo largo del litoral.

[Traducción de los autores]

The breeding distribution of the Osprey (*Pandion haliaetus*) in the Western Palearctic is patchy. Northern populations, especially those of Fennoscandia and Russia, are large and secure, while those of the south, in the Mediterranean region and Macaronesia, are relict and endangered (Sau-

rola 1997, Schmidt 1998). Formerly, the species bred in all Macaronesian islands, except for the Azores. In the Canary Islands the Osprey has undergone a marked decline (González et al. 1992), whereas in the Madeira Islands it was extirpated long ago (Palma 2001). Yet, several toponymic references remain along sea cliffs as evidence of the Osprey's occurrence in the past.

In the Cape Verde Islands, the Osprey was prob-

¹ E-mail address: lpalma@ualg.pt

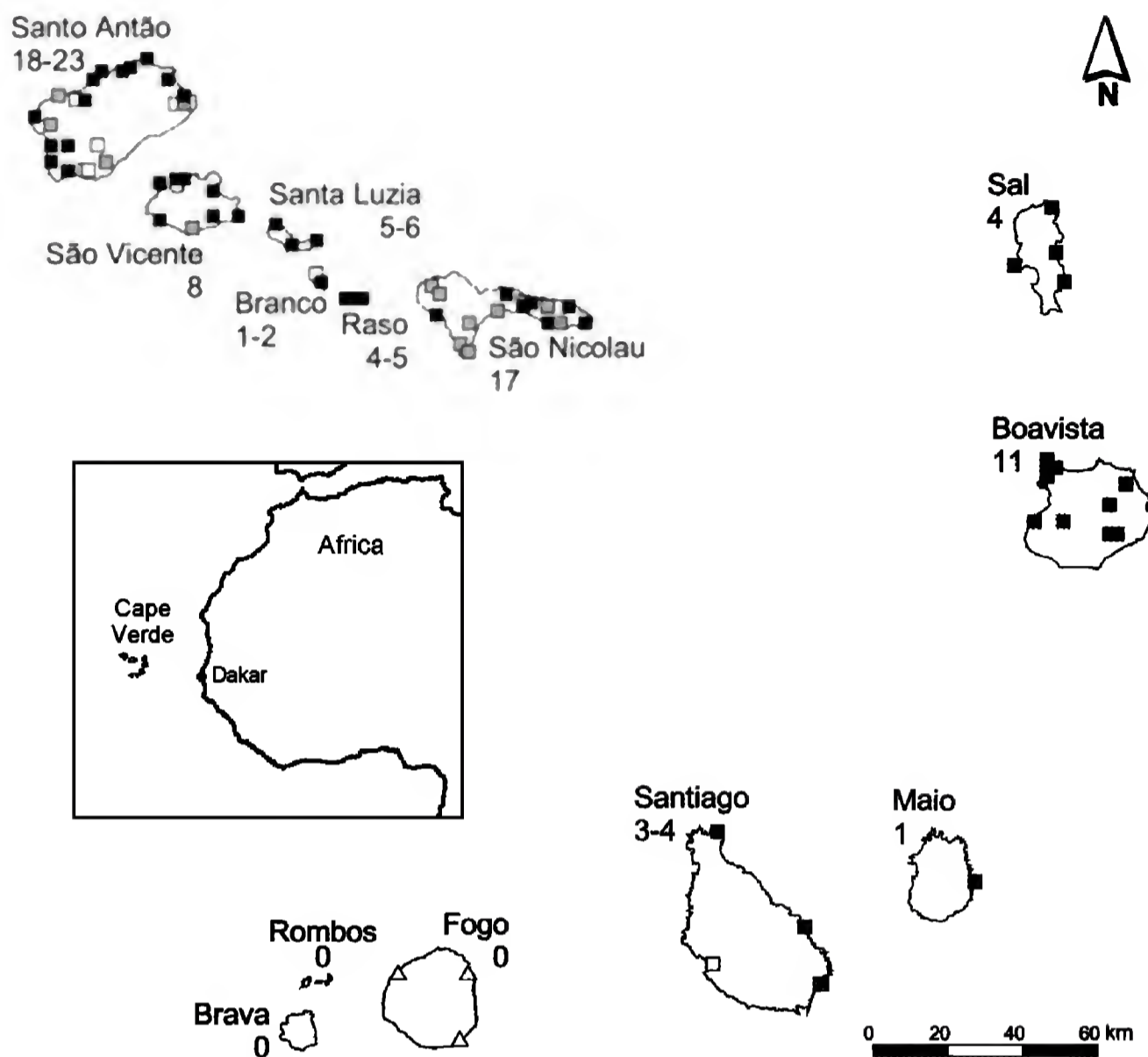


Figure 1. Geographic location of the Cape Verde Islands and distribution of Osprey breeding territories: confirmed (black squares), probable (gray squares), possible (open squares), and deserted (open triangles). Figures indicate the estimated number of pairs per island.

ably common during the 19th century and the first half of the 20th century, as suggested by the scanty and imprecise references available (e.g., Alexander 1898, Murphy 1924, Bourne 1955). Naurois (1987) estimated the population during the 1960s at 45–70 pairs, plus one possible extra pair in the islets of Rombos, based on an old nest observed. However, these figures resulted from general ornithological observations, and not from a species-targeted census. Also from incidental observations, Hazevoet (1995) estimated about 50 pairs for the period 1988–93. More recently, R. Dennis and S. Hille (pers. comm.) estimated the slightly higher number of 55–65 pairs, extrapolated from the pairs and occupied nests observed in 1996–97.

Here, we present the results of an Osprey survey carried out in the Cape Verde Islands in 1998–99, with further surveys of some poorly covered areas in June–July 2001. We assessed the current population and conservation status to provide up-to-

date data for the species' conservation. Preliminary results from this survey were presented by Ferreira and Palma (2000).

STUDY AREA AND METHODS

The Cape Verde archipelago (4026 km²; 1047 km coastline perimeter) is made up of 10 islands and six larger islets, about 500 km off continental west Africa between 14°48'–17°12'N and 22°44'–25°22'W (Fig. 1). With the exception of Santa Luzia and the islets, all the islands are inhabited.

The islands' physiography varies widely, ranging from the highly rugged Santo Antão, São Nicolau, Santiago, Fogo, and Brava to the relatively flat Sal, Boavista, and Maio. The coast of the mountainous islands is steep with high rocky cliffs and sea stacks interspersed by small to medium-sized pocket beaches, whereas in the low islands the littoral zone is predominantly bordered by extensive sandy beaches and low near-shore islets.

Preliminary Data Collecting. Prior to fieldwork, we gathered all available data on the species in Cape Verde from the literature, mapped toponymy as well as unpubl. data from various observers, mainly C. Hazevoet and S.

Table 1. Osprey survey effort, and checking of toponymies, literature references, and pers. comm. indicating Osprey locations in the Cape Verde Islands (1998–2001).

ISLANDS	ALTITUDE ^a	SURVEY EFFORT ^b	TOPONYMIES		REFERENCES	
			VERIFIED	UNVERIFIED	VERIFIED	UNVERIFIED
Santo Antão	1979	0.326 (44)	2	1	5	0
São Vicente	774	0.315 (29)	5	1	8	0
Santa Luzia ^c	395	—	0	0	0	2
Branco ^c	327	—	0	0	1	1
Raso	164	0.210 (2)	0	0	4	0
São Nicolau	1304	0.103 (14)	4	0	4	0
Sal	406	0.124 (11)	1	0	7	0
Boavista	390	0.183 (22)	5	0	15	0
Maio	436	0.075 (6)	0	0	4	0
Santiago	1392	0.174 (35)	1	1	8	0
Fogo	2829	0.131 (11)	6	0	4	0
Brava	976	0.217 (9)	0	0	1	0
Rombos ^c	96	—	0	0	0	2
Total		(183)	24	3	61	5

^a Maximum altitude in meters.

^b No. man-d (in brackets)/km of coastline.

^c No systematic survey carried out by the authors.

Hille (pers. comm.). We considered toponymy valuable information because the common name of the Osprey in both Portuguese and Capeverdean Creole (“guincho”) can be considered a reliable reference to traditional Osprey nest sites. Such toponymies are common in current and presumed former breeding areas along the coasts of southwestern Portugal, the Madeira archipelago, the Canaries, and the Cape Verdes. Examples from the latter are “Tope do Guincho” (Top of the Osprey), “Ponta Ninho do Guincho” (Point of the Osprey Nest), and “Ninho do Guincho” (Osprey Nest), among 27 sites (Table 1) that were checked for their current occupancy status.

Field Surveys. We carried out a comprehensive field survey, searching for territorial pairs and nest sites from December 1997–April 1999 throughout the archipelago, with the exception of Santa Luzia and the Islets of Branco and Rombos. Fieldwork was designed to encompass the Osprey extended breeding season in the islands that begins in late November (Naurois 1987, Hazevoet 1995).

We conducted an overall search in 1998. The following yr, we followed this effort with more intensive searches in the rugged islands of Santo Antão and São Nicolau, and checking of previously detected territories in São Vicente, Sal, Boavista, Maio and Santiago. From May–September 2001, we further verified some unconfirmed sites in Santo Antão.

We looked for birds and nests systematically, trying to cover the whole of both the coast and the hinterland of the islands, whether or not there were historic sites. Primarily, the search was done by motorcycle, car, and foot with binoculars and telescope, either along roads, tracks and footpaths or from lookouts. Whenever needed and feasible, the coasts were also viewed by boat from the sea.

Regularly, we interviewed local residents in rural and

fishing communities to collect information on the location of current and old nest sites, and areas where the species was observed commonly in the recent past. Information was complemented by that of other observers in the cases of Branco (March 1999; T. Clarke pers. comm.), and Santa Luzia and Rombos (October 1999 and February 2001, respectively; P.L. Suárez pers. comm.).

Birds and nests found were mapped on 1:25 000 topographic maps of the Republic of Cape Verde published by the Portuguese Army Geographical Institute. Breeding territories were mapped on an ArcView GIS (Environmental Systems Research Institute, Inc., Redlands, CA, U.S.A) simplified overlay (Fig. 1) of the 1:500 000 digital map of the Cape Verde Islands of the Portuguese Army Geographical Institute. Each territory was plotted by the geographic coordinates of the center of the correspondent 2 × 2 km UTM square, read from the 1:25 000 topographical maps.

Survey Effort. We calculated an index of the relative survey effort on each island, relating the number of man-d of fieldwork per island with its perimeter, measured with a curvimeter on the 1:25 000 topographic maps (No. man-d/km of coastline). Santa Luzia, Branco, and Rombos were not included in these estimates because information was mainly based on incidental data collected by other observers.

Population Status and Trends. We classified Osprey breeding territories as *confirmed*, *probable*, or *possible*, according to birds’ observed behavior, frequency and type of sightings at a given location (foraging activities were discarded), and nest occupancy. *Confirmed*—adults or young on nest, pairs seen (>3 times) within a restricted area, solitary adults seen (>3 times) close to unoccupied nests or where information collected strongly supports

Table 2. No. of individual sightings, nests observed, and nest occupancy status of the Osprey in the Cape Verde Islands (1998–2001).

ISLANDS	OSPREY SIGHTINGS	NESTS VERIFIED	PERCENT NESTS OCCUPIED	PERCENT NESTS UNOCCUPIED	PERCENT NESTS ABANDONED
Santo Antão	78	16	56	38	6
São Vicente	70	12	58	42	0
Santa Luzia	—	5 ^a	—	—	—
Branco	—	0	—	—	—
Raso	12	7	71	29	0
São Nicolau	63	10	60	10	30
Sal	14	10 ^b	40	20	40
Boavista	75	25 ^b	32	32	36
Maio	5	1	0	0	100
Santiago	7	4	50	50	0
Fogo	0	3	0	0	100
Brava	0	0	0	0	0
Rombos	0	—	—	—	—
Total	324	93 ^c	47	29	24

^aJ. M. Semedo and P. L. Suárez (pers. comm.).

^bIncludes nests reported by Barone and Delgado (1998; see text).

^cOccupancy totals calculated from 88 nests (i.e., excluding Santa Luzia).

breeding. *Probable*—pairs seen (<3 times) where information supports breeding, a pair and solitary adults observed on different occasions within a restricted area, solitary adults seen twice close to unoccupied nests, or solitary adults observed 2–3 times where information supports breeding. *Possible*—a pair seen displaying, a pair and a solitary adult observed on different occasions within a restricted area, solitary adults seen once near an unoccupied nest, or areas with no adults or nests seen but with supporting information suggesting breeding.

To categorize each nest as *occupied* (with eggs or young, or at least attended [i.e., repaired and ornamented]), *unoccupied* (i.e., presently unattended, but still well preserved), or *abandoned* (decaying) we spent only the time needed to view its contents and condition, and to assess presence or absence of birds. We assumed that unoccupied nests were either (1) alternate nests, thus one occupied nest should exist within the territory, or (2) temporarily *not* occupied, i.e., observed out of the breeding season or not occupied due to breeding failure during the study period.

In evaluating trends, we calculated a minimum change in number of nests per island, comparing the mean values of two estimates (Naurois 1987 and this study). The difference found is presented as a percentage of the mean value of Naurois's estimate.

RESULTS

Survey Effort and Land Coverage. During 183 man-days of fieldwork, about 94% of 988-km (the total coastal perimeter of the archipelago, excluding Santa Luzia, Branco, and the Rombos) was surveyed. In general, survey effort was higher in is-

lands of rougher ground (e.g., Santo Antão; Table 1) to compensate for the lower conspicuousness of birds and nests. São Nicolau and Fogo were exceptions due to the relatively high accessibility of the coastal belt. Santiago, despite over 30 man-d of survey, remained at a comparatively low effort rate due to the large size of the island (Table 1). We checked 89% of all toponymies and 92% of historical references for the presence of Ospreys.

Birds and Nests Observed, and Nest Occupancy. Our surveys yielded 324 sightings of Ospreys (Table 2) and 83 nests. Four additional nests were reported from Boavista and one from Sal during the study period (Barone and Delgado 1998, Barone et al. 1999). Furthermore, in Santa Luzia, two nests were found incidentally by J.M. Semedo (pers. comm.) in 1998 and three others by the "Cabo Verde Natura 2000" team in 1999 (P.L. Suárez pers. comm.). Altogether, we recorded 93 nests during the study period (Table 2).

In calculating percent occupancy, we did not consider nests reported from Santa Luzia due to lack of details. Of the remaining 88 nests, 41 (47%) were occupied, 26 (29%) unoccupied, and 21 (24%) abandoned. Except in Fogo, abandoned nests were mainly located on the eastern "flat" islands (Sal, Boavista, and Maio), and on São Nicolau (Table 2). In Fogo, only abandoned nests were

Table 3. Present and former (1960s; Naurois 1987) Osprey population estimates, densities, and recent population trends in the Cape Verde Islands.

ISLANDS	1998–2001 ESTIMATE ^a	DENSITY ^b	NAUROIS'S ESTIMATE	PERCENT CHANGE
Santo Antão	18–23	0.15	8–11 ^c	+115.8
São Vicente	8	0.09	3–6	+77.8
Santa Luzia ^d	5–6	0.17	3–4	—
Branco ^d	1–2	0.18	3–4	—
Raso	4–5	0.47	1–2	+200
São Nicolau	17	0.13	5–8 ^c	+161.5
Sal	4	0.04	6–8	–42.9
Boavista	11	0.09	5–8	+69.2
Maio	1	0.01	2–3	–60
Santiago	3–4	0.02	4–6 ^c	–30
Fogo	0		2–5 ^c	–100
Brava	0		3–5	–100
Rombos	0		1?	–100
Total	72–81	0.13	46–71	+31 ^e

^a No. of estimated territories/pairs; lower estimates include confirmed and probable territories.

^b Mean No. estimated pairs/km of coastline.

^c Crude estimates according to Naurois (1987), hence corresponding percent change is unreliable.

^d Percent change not calculated due to the unreliability of current estimates.

^e Overall percent change calculated from totals excluding Santa Luzia and Rombos.

recorded, and in Brava no nests or birds were found. In the Rombos, P.L. Suárez (pers. comm.) also did not find any evidence of Osprey use in 2001.

Nests were built on the top of pinnacles (18%), on isolated sea rocks (14%), on rock ledges on steep slopes (14%), on hilltop peaks and crests (12%), on sea-cliff ledges and fallen blocks (10%), on protruding rock platforms on gentle slopes (21%), on level ground by the shore (5%), and on flat near-shore islets (1%). The first five types of nest sites predominate on mountainous islands, while the others are typical of the flatter islands. We also found a few nests atop masts of stranded vessels (5%). Nesting on the crown of palms (*Phoenix atlantidis*) (Hazevoet 1995, Ontiveros 2003) and on the sand (S. Hille pers. comm.) has also been reported from Boavista. This high plasticity in the choice of nest sites, comparable to that found by Bretagnolle et al. (2001) in New Caledonia, had already been described by Naurois (1987).

Distribution, Population Estimates, and Trends.

We initially estimated the Osprey population at 54–81 pairs within the area surveyed (54 confirmed, 18 probable, and 9 possible). However, we considered the lower value (confirmed pairs) too conservative as both the comparison between 1998 and 1999 censuses in Sal and Boavista, and the check-

ing of unconfirmed sites at Santo Antão in 2001, indicated that most of the probable pairs would likely be confirmed with enough fieldwork. Therefore, we believed that adding both confirmed and probable pairs would offer the more realistic estimate of 72–81 pairs in 1998–99 (Table 3). The preliminary figure of 5–6 pairs in Santa Luzia is based on data provided by P.L. Suárez (pers. comm.).

The highest numbers of Osprey pairs are in Santo Antão, São Nicolau, and Boavista, which account for 37% of the coastline and 63–64% of the Osprey population. The majority, 94% of Osprey pairs are concentrated in the Barlavento (“windward”) group (Santo Antão ↔ Boavista; 60% of the coastline), in contrast with only 6% of the population in the Sotavento (“leeward”) group (Maio ↔ Brava; 40% of the coastline; Table 3, Fig. 1).

Mean linear densities (Table 3) are much higher in the Barlavento (0.16 pairs/km of coastline) than in the Sotavento (0.01 pairs/km). Density is especially high in the small islet of Raso (0.47 pairs/km).

The comparison between the present estimate and Naurois (1987) suggested that during the last three decades, upward trends occurred in Santo Antão, Raso, and São Nicolau, and moderate positive changes in São Vicente and Boavista, all in the Barlavento (Table 3). However, the figures for San-

to Antão and São Nicolau should be taken with caution because Naurois's estimates were not made systematically.

The trends were negative in Sal, Maio, Santiago, Fogo, Brava, and Rombos, which, apart from Sal, are all in the Sotavento. At the last three islands there was no evidence of Osprey presence. In Santiago the percent of change must also be viewed with caution because of the uncertainty of Naurois' estimate. The overall trend in the archipelago is positive.

DISCUSSION

Nest Occupancy. The interpretation of present nest occupancy during a short-term study is limited by the fact that these estimates are not independent of the number of extant alternate nests. Such alternate nests are common all over the archipelago, especially in islands of milder topography, probably as a way to avoid natural and human predation or disturbance. In Boavista, where human interference and predation by Brown-necked ravens (*Corvus rufficollis*) are presumably high, P.L. Suárez (pers. comm.) has recorded that nests outnumber pairs by 3–4 times. Although the variety of nesting situations suggests that breeding habitat is not a limiting factor in the species distribution in general, the vulnerability of many nest sites in the eastern islands is probably impairing reproduction.

The percent occupancy of nests (Table 2) is clearly lower at islands such as Sal, Boavista, and Maio, where potential disturbance is higher. In Boavista, low occupancy rates have also been reported by other observers (Ontiveros 2003, P.L. Suárez pers. comm.). A tendency to desert near-shore nests seems evident at this island and may eventually cause the disappearance of pairs occupying areas of level or slightly broken terrain (Ontiveros 2003). In São Nicolau, despite its steep-land mountains, the number of abandoned nests was also high probably due to their vulnerable locations by the shore. In New Caledonia, Bretagnolle et al. (2001) also reported a tendency of Ospreys to desert nests exposed to human disturbance, especially those on the ground. High nest vulnerability may explain the Osprey decline in Sal and Maio.

Conversely, in mountainous islands such as Santo Antão, São Vicente, and Santiago, less accessible nests predominate, as well as low percentages of abandoned nests. However, all nests found in Fogo were abandoned, despite being located in inacces-

sible places, so disturbance is unlikely to be the cause of desertion at the island.

Population Status and Trends. Apart from Santo Antão and São Nicolau, Naurois (1987) considered the Barlavento well surveyed. In São Nicolau, however, birds and nests are relatively conspicuous, so the numbers he reported were probably fairly accurate. Therefore, we believe, with the exception of Sal, that a genuine population increase has occurred for the Barlavento since Naurois' time.

The population recovery in the Barlavento likely resulted from a decreasing intensity of the collecting of eggs and nestlings reported by Naurois (1964). This was corroborated by statements of residents during our study and seems particularly obvious in São Vicente, where the present situation contrasts with what Naurois formerly described as near extirpation of Osprey due to overharvesting.

Opposite of the pattern observed in the Barlavento, a depression in numbers was still evident in all islands of the Sotavento, where the Osprey has apparently always been less abundant. Naurois (1987) suggested that variation in prey availability may explain the differences in Osprey numbers using these two groups of islands. The Osprey population seems to be most depressed further to the southwest (Table 3). In particular, the decaying state of the nests found in Fogo and the lack of any trace of Osprey presence in Brava and Rombos suggest that the species has been extirpated from these islands as a breeder.

ACKNOWLEDGMENTS

We are deeply indebted to Cornelis Hazevoet, Sabine Hille, Phil Hansbro, Tony Clarke, José Maria Semedo, and Pedro López Suárez for the valuable unpubl. data provided. We thank Aníbal Medina and Edério Almada in the Instituto Nacional de Desenvolvimento das Pescas (INDP) of Cape Verde for their continuous support. We also thank Pedro Beja, Cornelis Hazevoet, Sabine Hille, Ian Warkentin, Mark Martell, and an anonymous referee for their critical review of the manuscript; Carla Janeiro for drawing the map; and others that helped us in various ways. We owe a final word of thanks to the prompt and genuine "morabeza" of the people of the Cape Verde Islands. This study was funded by the Sudoeste Alentejano e Costa Vicentina Natural Park and the Instituto Português da Juventude (Lusíadas programme) of Portugal, and the FAO-"Fisheries Development" programme of Cape Verde.

LITERATURE CITED

- ALEXANDER, B. 1898. An ornithological expedition to the Cape Verde Islands. *Ibis* 4:74–118.
- BARONE, R. AND G. DELGADO. 1998. Observaciones ornitológicas en el archipiélago de Cabo Verde, Septiem-

- bre–Octubre de 1998. II. Aves nidificantes. *Rev. Acad. Canar. Cienc.* 10:41–64.
- , M.F. DEL CASTILLO, AND J.J. BACALLADO. 1999. Nueva contribución a la ornitología de Cabo Verde. Observaciones de interés en las islas de Barlovento, Abril de 1999. *Rev. Acad. Canar. Cienc.* 9:173–187.
- BOURNE, W.R.P. 1955. The birds of the Cape Verde Islands. *Ibis* 97:508–556.
- BRETAGNOLLE, V., M. PANDOLFI, V. LECOQ, AND J. BROUDISSOU. 2001. Le balbuzard pêcheur *Pandion haliaetus* en Nouvelle-Calédonie: effectif, répartition et menaces. *Alauda* 69:491–501.
- FERREIRA, J. AND L. PALMA. 2000. The Osprey (*Pandion haliaetus*) in the Cape Verde Islands: distribution, population trends and conservation problems. Pages 721–727 in R.D. Chancellor and B.-U. Meyburg [EDS.], *Raptors at Risk*. World Working Group on Birds of Prey and Owls/Hancock House, Berlin, Germany.
- GONZÁLEZ, G., J.M. SANTIAGO, AND L. FERNÁNDEZ. 1992. El águila pescadora (*Pandion haliaetus*) en España. Censo, reproducción y conservación. Colección Técnica. ICONA, Madrid, Spain.
- HAZEVOET, C.J. 1995. The birds of the Cape Verde Islands. *British Ornithologists' Union Check-list* 13. British Ornithologists' Union, Tring, Hertfordshire, U.K.
- MURPHY, R.C. 1924. The marine ornithology of the Cape Verde Islands, with a list of the birds of all the archipelago. *Bull. Amer. Mus. Nat. Hist.* 50:211–278.
- NAUROIS, R. 1964. Les oiseaux des îles du Cap-Vert. Suggestions en vue de leur sauvegarde. *Garcia de Orta, IICT*, Lisboa 12:609–620.
- . 1987. Le Balbuzard (*Pandion haliaetus* L.) aux îles du Cap Vert. *Ann. Mus. Civ. Stor. Nat. Genova* 86:657–682.
- ONTIVEROS, D. 2003. Nesting distribution, food habits, and conservation of Osprey on Boavista Island (Archipelago of Cape Verde). *J. Raptor Res.* 37:67–70
- PALMA, L. 2001. The Osprey (*Pandion haliaetus*) on the Portuguese coast: past, present and recovery potential. *Vögelwelt* 122:179–190.
- SAUROLA, P. 1997. The Osprey (*Pandion haliaetus*) and modern forestry: a review of population trends and their causes in Europe. *J. Raptor Res.* 31:129–137.
- SCHMIDT, D. 1998. Osprey (*Pandion haliaetus*) breeding numbers in the western Palearctic. Pages 323–326 in R.D. Chancellor, B.-U. Meyburg, and J.J. Ferrero [EDS.], *Holarctic birds of prey*. World Working Group on Birds of Prey and Owls and Asociación para la Defensa de la Naturaleza y los Recursos de Extremadura, Mérida, Spain.

Received 13 June 2003; accepted 19 January 2004

Associate Editor: Ian G. Warkentin

SHORT COMMUNICATIONS

J Raptor Res. 38(2):148–152

© 2004 The Raptor Research Foundation, Inc.

DEVELOPMENT OF HUNTING BEHAVIOR IN HACKED APLOMADO FALCONS

JESSI L. BROWN,¹ WILLIAM R. HEINRICH, J. PETER JENNY, AND BRIAN D. MUTCH
The Peregrine Fund, 5668 W. Flying Hawk Lane, Boise, ID 83709 U.S.A.

KEY WORDS: *Aplomado Falcon*; *Falco femoralis*; *cooperative hunting*; *foraging behavior*; *hacking*; *Texas*; *hunting behavior*.

The extent to which hunting is instinctive in young raptors as proposed by Brown and Amadon (1968) is difficult to investigate in wild populations. Parents of many species entice fledglings by carrying prey items, release or flush live prey in the vicinity of fledglings, and accompany them on hunting forays (Newton 1979, Schaadt and Rymon 1982, Sherrod 1983). However, numerous restoration projects involving the release (“hack”) of young raptors into the wild, as developed centuries ago by falconers, have shown that hunting proficiency readily develops in the absence of parents (Sherrod 1983, Mutch et al. 2000). Moreover, hacked raptors may develop at rates similar to their wild counterparts; for example, hacked Peregrine Falcons (*Falco peregrinus*) and Red-necked Falcons (*Falco chicquera*) fledged and began killing prey at ages comparable to those in wild populations (Sherrod 1983, Bednarek 1993). The “hacking” procedure therefore facilitates the study of innate components involved in the ontogeny of hunting behavior.

The northern Aplomado Falcon (*Falco femoralis septentrionalis*) is particularly suited to such investigations as it is naturally tolerant of human presence and easily observed in its open savanna habitat, where it typically hunts from isolated perches. Of further interest is that adult pairs hunt cooperatively for avian prey, a mode that Hector (1986) believed an inherent tendency as based on his observations of breeding adults in eastern Mexico. In this report, we summarize our records and those of numerous observers who attended the development of hacked Aplomado Falcons released by The Peregrine Fund in Texas since 1993. Herein, we describe the development of their hunting behavior in the absence of parental influence.

METHODS

Study Area. Falcons were released in Texas ($N = 25$ release sites) at three focal areas: the lower Rio Grande valley in the vicinity of Laguna Atascosa National Wildlife Refuge (NWR); the coastal bend of southeastern Texas,

including Aransas NWR and Matagorda Island NWR; and western Texas in Jeff Davis County. Vegetation at sites included savanna, coastal prairie, and Chihuahuan grassland/desertscrub (see McAlister and McAlister 1995, Perez et al. 1996, Powell 2000).

Methods. Procedures for the release of Aplomado Falcons were modified from those developed for Peregrine Falcons (Sherrod et al. 1987, Mutch et al. 2000). Following a pilot study in 1986–89, large-scale releases of Aplomado Falcons began in 1993 and continued through 2002, with 354 female falcons and 443 male falcons released during that period. At about 30 d of age, young falcons were transported to release sites in Texas; these featured 3–5 m tall towers, each topped with a release box facing away from an observation blind. Release groups of 2–8 falcons were placed within similar-aged cohorts regardless of gender. While still in release boxes, the falcons were fed and monitored by attendants. Boxes were opened when falcons were 38–41 d old, and the attendants continued to provide food and monitor the site daily for 6 wk following release. All falcons were banded with Geological Survey bands and anodized aluminum color bands with 1–2 alphanumeric characters, allowing attendants to identify individuals from a distance. Falcons were continuously observed during daylight hours for the first 3 d following a release, and then during morning and evening hours only (dawn to 1100 H and 1500 H to dusk). Following the close of a release site, attendants provided reports summarizing the releases, dispersal, hunting behaviors, and unusual events observed at that site.

We extracted data from 46 project reports from 1993–2002 representing 22 release sites. Hunts were classified to mode as either solitary or group, with all hunts involving two or more falcons termed “group hunts,” regardless of notes suggesting the hunts could be considered group, pseudocooperative, or cooperative (Ellis et al. 1993). Kills were recorded when a hunt ended successfully, or circumstantially determined when a falcon was seen with prey other than that supplied at the hack tower. We recorded 305 separate hunts, including 30 putative (circumstantial) kills, or 6.6 (95% Confidence Interval = ± 1.8 , range 1–26) per site/yr.

Statistical Analyses. We pooled data from west and south Texas, as separate analyses showed similar mean values and widely overlapping 95% confidence intervals (for age at first pursuit; female in south Texas, $N = 65$, \bar{x} age = 63.9 d, 95% CI = ± 3.1 ; female in west Texas, $N = 11$, \bar{x} age = 65.7 d, 95% CI = ± 7.9 ; males in south

¹ E-mail address: jbrown@peregrinefund.org

Table 1. Comparison by gender of first vertebrate pursuits and vertebrate kills in hacked Aplomado Falcons. Values are means in days (95% confidence intervals).

	FEMALE			MALES		
	\bar{x}		<i>N</i>	\bar{x}		<i>N</i>
First pursuits						
Age	64.1	(61.4–66.9)	76	59.1	(56.2–62.0)	78
Days since release	24.3	(21.5–27.0)	76	18.5	(15.5–21.4)	78
First kills						
Age	73.1	(67.1–79.0)	19	74.8	(69.3–80.4)	19
Days since release	32.4	(26.5–38.4)	19	34.8	(29.4–40.2)	19

Texas, $N = 69$, \bar{x} age = 58.1 d, 95% CI = ± 2.8 ; males in west Texas, $N = 9$, \bar{x} age = 66.8 d, 95% CI = ± 14.3). Our assumption that the behavior of each falcon was independent of its release cohort was supported by *F*-tests which showed that inter-cohort behavior was as variable as intra-cohort behavior (for age at first vertebrate pursuit: females, $F = 0.81$, $df = 52$, $P = 0.22$; males, $F = 0.91$, $df = 47$, $P = 0.37$). We compared differences between behaviors exhibited by male and female Aplomado Falcons, age differences at first solitary and first group pursuit of vertebrate prey by each individual, and temporal distribution and relative success of hunting modes. Data are expressed as means and 95% confidence intervals (95% CI) unless otherwise stated.

RESULTS AND DISCUSSION

Pursuit and Capture of Invertebrates. All sites reported hacked falcons chasing, capturing, and consuming insects from soon after release through the end of the observation periods (42 d after release). Pursuit of insects was so common that many attendants summarized rather than detailed specific hunts. Falcons caught insects in the air, plucked them from branches and grass stems, and pursued them by running on the ground. Groups of falcons chased the same insect, and falcons occasionally pirated insect prey from each other. At two sites, falcons gathered along the margins of controlled-burn plots and chased insects flushed from cover by the flames. Along the Texas gulf coast, falcons caught and consumed sand fiddler crabs (*Uca panacea*) locally abundant on tidal flats and in marshy areas (McAlister and McAlister 1995).

Pursuit of Vertebrates. Falcons pursued 67 species of vertebrates as apparent hunting targets, and 34 species during territorial defense or other aggression, the latter easily differentiated by the falcons' loud "kekking" vocalization (Keddy-Hector 2000). Raptors and large mammals evoked defensive behavior most frequently, but falcons also attempted to drive away an armadillo (*Dasyurus novemcinctus*) and a Texas tortoise (*Gopherus berlandieri*).

All 275 vertebrate hunting attempts were directed towards birds, but two mammals and four reptiles were observed amongst the putative kills. Falcons typically flew directly from a perch toward prey in trees, on the

ground, or flying past. The two largest species pursued with apparent hunting intent were Great Blue Heron (*Ardea herodias*: males 2576 g, $N = 17$; females 2204 g, $N = 15$) and Roseate Spoonbill (*Ajaia ajaja*: males 1240–1750 g, females 1400–1700 g; no sample size reported), and the smallest was the Ruby-throated Hummingbird (*Archilochus colubris*: males 3.0 g, $N = 202$; females 3.3 g, $N = 489$). The largest reported kill by the hacked falcons was a Mourning Dove (*Zenaidura macroura*: males 123 g, $N = 140$; females 115 g, $N = 95$; Dunning 1993).

Sex Differences. Attendants recorded the first known vertebrate hunts for 154 individual falcons. Males pursued vertebrates earlier than females, measured both in age and d since release (Table 1). Kills were witnessed in 35 first successful vertebrate hunts, and an additional 30 putative kills were determined circumstantially. Of 38 first kills by known falcons, 19 were by females and 19 by males. Ages and d since release were similar for these falcons (Table 1).

Our data on the onset of vertebrate pursuit behavior agree with other studies of falcon development: the sexes of hacked Aplomado Falcons developed at different rates. Sherrod (1983) found that hacked male Peregrine Falcons began their first pursuits of vertebrates at an earlier age than females (50.6 d versus 55.7 d, $N = 43$ and 41, respectively). However, if we assume that the putative kill component represented prey killed by the possessor, male and female Aplomado Falcons appeared to kill vertebrate prey at the same age (Table 1). More putative kills were ascribed to females than males (15 to females, 7 to males). Although this could represent piracy by larger females upon smaller males, observations suggest that the tendency is rare (2 successful piracies and 5 piracy attempts in 275 hunts).

In any case, once Aplomado Falcons began pursuing vertebrate prey, females progressed to prey acquisition more quickly than males. On average, females obtained prey about 10 d after the onset of pursuit behavior, compared to males at 15 d. Bednarek (1993) also reported first kills at ca. the same age for each sex of hacked Red-necked Falcons; 60 and 68 d for males ($N = 2$) and 63

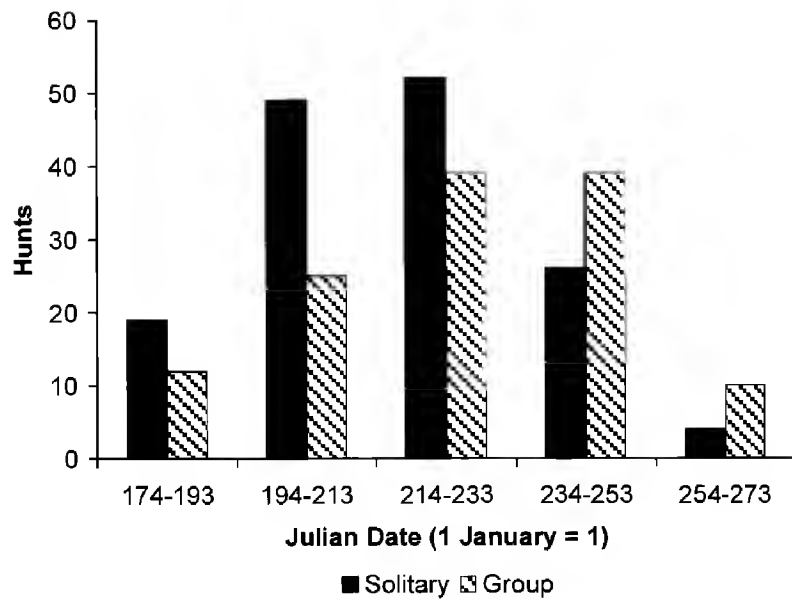


Figure 1. Incidence of solitary and group hunting by hacked Aplomado Falcons in Texas. Y-axis values are numbers of solitary and group hunts observed within 20-d intervals corresponding to first and last hunts observed (23 June–28 September 1993–2002).

and 69 d for females ($N = 2$). These results run counter to the often-held assumption that female raptors lag behind males in post-fledging development. Sherrod (1983) reported only a slight difference in the mean age of kills for peregrines (73.3 d for males and 76.8 d for females, $N = 62$ and 33, respectively).

Group Hunting. Of 275 pursuits of vertebrates reported as hunts, 125 involved more than one falcon (range 2–12 falcons) simultaneously chasing the same prey. Censoring hunts with group size reported merely as “group” ($N = 9$), 399 falcons participated in group hunts or 3.4 (95% CI = ± 0.3) participants per hunt. Of hunts with known outcomes, 20 of 122 (16%) group hunts were successful, whereas 15 of 150 (10%) solitary hunts succeeded. As the hacking periods progressed, group hunts were observed more often, and fewer solitary hunts were seen (Fig. 1). For the 23 falcons confirmed hunting both alone and in groups, there was no difference between the ages at first pursuit for either hunting mode (solitary = 59.4 d, 95% CI = ± 5.3 ; group = 60.3 d, 95% CI = ± 5.7). The increase in group hunts may therefore relate to factors other than the age of participants. It is quite possible that the prey base composition changed through the yr, with proportionally more recently-fledged, vulnerable passerines present in late summer. Moreover, the number of falcons per hack site increased throughout the season; at most sites, cohorts of falcons released sequentially throughout the hack season accumulated to a maximum of six cohorts per site, potentially presenting greater opportunities to participate in group hunts.

Group hunting commonly occurred at all hack sites. Although many group hunts were doubtless the consequence of several falcons coincidentally pursuing the same prey, detailed reports of group hunts suggested that some contained elements of cooperation. Ellis et al.

(1993) suggested that true cooperative hunts, as described for mated pairs, family groups, and sibling groups, would have certain characteristics. These included coordinated movements, sometimes with some members performing rushing attacks having a low probability of capture success in order to increase the group's chance of capture; social signals such as vocalizations to initiate or coordinate the hunt; and orderly prey sharing. Observations of the hacked falcons were sometimes consistent with these criteria (Appendix, observations 1–3).

Group hunting was not limited to cohorts of hacked falcon nest mates. Hack sites were regularly visited by falcons released at other sites, especially those closely spaced within Laguna Atascosa and Matagorda Island NWRs. These visitors were accepted with little hesitation by the local falcons, and would feed from the same tower and join in group hunts. In later years, juvenile falcons dispersing from wild nests, always a month or more older than the hacked falcons, appeared at hack sites, and were similarly tolerated (Appendix, observation 4). Territorial adult falcons, whether previously hacked or wild-produced, displayed aggression toward hacked falcons, but other adults interacted benignly with the juveniles (Appendix, observation 5).

Hector (1986) found that adult Aplomado Falcons were significantly more successful when hunting birds as pairs than when alone: 45% of pair attacks were successful versus 21% of solo hunts. Success rates calculated for our data favored group hunts as well (16% versus 10%). Even so, from the standpoint of prey acquisition by individual hacked Aplomado Falcons, group hunts were far less efficient than solitary hunts. For group hunts in which both group size and hunt outcome were known, 386 falcons participated in 113 group hunts of which 20 were successful, leading to a success rate of 5% per participant, less than one half the frequency of success recorded for solitary hunts (10%). Because group hunting by recently fledged falcons is likely precursory to the cooperative hunting of adult pairs and because food is not usually shared among juveniles participating in group hunts, adaptive payoffs of this behavior would appear to be delayed a yr or more.

Our findings support those of other studies that young raptors quickly acquire foraging skills in the absence of parental influence. However, the young hacked Aplomado Falcons behaved differently than Peregrine Falcons: groups of hacked peregrines rarely share food and their conspecific interactions are markedly more aggressive (B. Mutch pers. comm.). Instead, our data support those of Hector (1986), who theorized that cooperative hunting is innate in Aplomado Falcons. He noted that throughout the species' range mated pairs hunt together yr-round, both sexes vocalize to instigate participation by their mates in hunting and defense activities, different pairs show the same division of labor in hunts, and nestlings and fledglings are more passive toward one another than those of other falcon species. The behavior ob-

served among the hacked Aplomado Falcons was similar to that of foraging adult pairs. Young Aplomado Falcons persisted in group hunt participation despite the lack of immediate payoff, which points to future benefits associated with the early practice of such behavior.

RESUMEN.—Examinamos 275 registros de comportamiento de caza, incluyendo 125 grupos de caza, entre polluelos de halcones perdiceros (*Falco femoralis*) en el sur de Texas. En promedio, los halcones machos comenzaron a perseguir presas vertebradas 5 días más temprano que sus hembras “hermanas”, sin embargo ambos sexos mataron presas vertebradas a la misma edad. Mientras que los grupos de caza estuvieron más propensos a ocurrir más tarde en el año, los individuos de halcón perdicero no mostraron correlación entre la edad y la época cuando ellos participaron en la cacería cooperativa. Mas intentos de caza en grupo terminaron exitosamente (16% versus 10%); sin embargo, con una media de 3,4 participantes por grupo de caza, estos fueron mucho menos eficientes por participante (5% de oportunidades de éxito). Algunos grupos de caza mostraron características típicas de cacerías cooperativas exhibidas por las parejas de halcones perdiceros. Nuestras observaciones sugieren que los grupos de caza son innatos en los halcones Perdiceros y que las ineficientes cacerías en grupo de los jóvenes halcones pueden ayudar a desarrollar las habilidades sociales y las técnicas de caza necesarias para las futuras cacerías cooperativas con sus parejas.

[Traducción de César Márquez]

ACKNOWLEDGMENTS

This study was supported by The Peregrine Fund. We thank J. Belthoff, B. Burnham, M. Curti, H. McElroy, A. Montoya, A. Nicholas, and D. Whitacre for help throughout. We acknowledge the valuable observations and note-taking of countless hack site attendants. Comments by T. Cade, G. Hunt, S. Sherrod, and two anonymous reviewers improved earlier drafts of this manuscript.

LITERATURE CITED

- BEDNAREK, W. 1993. Controlled hacking, a method of research into the biology of non-indigenous raptors: the Red-headed Falcon *Falco chicquera chicquera*. Pages 207–212 in M.K. Nicholls and R. Clarke [EDS.], Biology and conservation of small falcons: proceedings of the 1991 Hawk and Owl Trust Conference. The Hawk and Owl Trust, London, U.K.
- BROWN, L.H. AND D. AMADON. 1968. Eagles, hawks, and falcons of the world. 2 vols. McGraw-Hill, New York, NY U.S.A.
- DUNNING, J.B. 1993. CRC handbook of avian body masses. CRC Press, Boca Raton, FL U.S.A.
- ELLIS, D.H., J.C. BEDNARZ, D.G. SMITH, AND S.P. FLEMING. 1993. Social foraging classes in raptorial birds. *BioScience* 43:14–20.
- HECTOR, D.P. 1986. Cooperative hunting and its relationship to foraging success and prey size in an avian predator. *Ethology* 73:247–257.
- KEDDY-HECTOR, D.P. 2000. Aplomado Falcon (*Falco femoralis*). In A. Poole and F. Gill [EDS.], The birds of North America, No. 549. The Birds of North America, Inc., Philadelphia, PA U.S.A.
- MCALISTER, W.H. AND M.K. MCALISTER. 1995. Aransas: a naturalist's guide. Univ. Texas Press, Austin, TX U.S.A.
- MUTCH, B.D., J.P. JENNY, W.R. HEINRICH, AND C.E. SANDFORT. 2000. The Northern Aplomado Falcon: biology, restoration, and hacking procedures. The Peregrine Fund, Inc., Boise, ID U.S.A.
- NEWTON, I. 1979. Population ecology of raptors. Buteo Books, Vermillion, SD U.S.A.
- PEREZ, C.J., P.J. ZWANK, AND D.W. SMITH. 1996. Survival, movements, and habitat use of Aplomado Falcons released in southern Texas. *J. Raptor Res.* 30:175–182
- POWELL, A.M. 2000. Grasses of the Trans-Pecos and adjacent areas. Iron Mountain Press, Marathon, TX U.S.A.
- SCHAADT, C.P. AND L.M. RYMON. 1982. Innate fishing behavior of Ospreys. *Raptor Res.* 16:61–62.
- SHERROD, S. 1983. Behavior of fledgling Peregrines. The Peregrine Fund, Inc., Ithaca, NY U.S.A.
- , W.R. HEINRICH, W.A. BURNHAM, J.H. BARCLAY, AND T.J. CADE. 1987. Hacking: a method for releasing Peregrine Falcons and other birds of prey. The Peregrine Fund, Inc., Boise, ID U.S.A.

Received 12 January 2003; accepted 16 November 2003

APPENDIX—SELECTED OBSERVATIONS

1. A group of four falcons (64.8 ± 5.5 d old) chasing a Cliff Swallow (*Petrochelidon pyrrhonta*) surrounded it such that, as it tried to escape from one pursuing falcon, it met another in its path. Eventually the swallow sought refuge in a mesquite tree (*Prosopis glandulosa*) only to be flushed by one falcon as the others waited nearby and resumed the chase. Later, at least 10 falcons chased a pair of Loggerhead Shrikes (*Lanius ludovicianus*) in the same manner. The falcons gave short “chipping” vocalizations characteristic of those exhibited by mated pairs during cooperative hunts (Keddy-Hector 2000, Peregrine Fund unpubl. data) Both hunts were unsuccessful, but 8 d later three of the falcons (81 ± 1 d old) from the first hunt, caught a Cliff Swallow after chasing it high in the air. The successful falcon fed on his prey while the other two watched intently but passively.
2. Observers witnessed a successful hunt by five falcons on an Eastern Meadowlark (*Sturnella magna*). As it tried to escape across the open landscape, three falcons tail-chased, while two stooped from above. On the following d, a group of six falcons caught a small bird in the same manner. One month later, groups chased and killed Eastern Kingbirds (*Tyrannus tyrannus*).

- nus*). During one hunt, eight falcons chased a kingbird for about 1 min until it sought refuge in a mesquite. The falcons followed it, with five waiting in the treetop while three others ran and hopped through the lower branches until the kingbird flushed and was captured, a sequence often exhibited by mated pairs (Keddy-Hector 2000).
3. In 1993, a group of seven falcons chased and caught a Ladder-backed Woodpecker (*Picoides scalaris*). Several falcons fed on it simultaneously, while the others settled on perches nearby. When a Northern Harrier (*Circus cyaneus*) approached the kill site, two of the non-feeding falcons left the group and drove the harrier away while the others continued their meal undisturbed (C. Perez pers. comm.).
 4. A wild hatch-year (HY) male falcon was found eating prey while perched on the rafters underneath one of the hack boxes. Attendants reported that this falcon "generously shared" his kill, possibly a swallow, with a female hacked falcon.
 5. A wild-hatched adult female arrived at a hack site and led the first successful group hunt of the yr. She captured a meadowlark after chasing it together with two HY hacked falcons, all three stooping in turn. At a different hack site, a previously hacked adult female regularly visited from 1999–2002. This falcon occasionally fed from the tower, joined in hunts and tower defense, and tolerated food-begging from the HY falcons. Attendants described her behavior as "mentoring."

J Raptor Res. 38(2):152–157

© 2004 The Raptor Research Foundation, Inc.

SUMMER ROADSIDE RAPTOR SURVEYS IN THE WESTERN PAMPAS OF ARGENTINA

MICHAEL I. GOLDSTEIN¹ AND TOBY J. HIBBITTS²

Texas A&M University, Department of Wildlife and Fisheries Sciences, 2258 TAMU, College Station, TX 77843 U.S.A.

KEY WORDS: *Chimango Caracara*; *Milvago chimango*; *Crested Caracara*; *Caracara plancus*; *agriculture*, *mesquite*, *Argentina*, *survey*.

Roadside surveys are useful for assessing habitat preferences of diurnal raptors. Although the limitations and biases inherent in roadside counts are well known (Fuller and Mosher 1987), roadside surveys serve as a practical means for rapidly assessing raptor distribution and abundance over large areas (Ellis et al. 1990). Roadside surveys have been used to compare species richness and abundance between broad regions and to assess impacts of anthropogenic-habitat transformations on raptors. These types of surveys have been carried out in Europe (Meyburg 1973), Africa (Cade 1969), North America (Woffinden and Murphy 1977), Latin America (Ellis et al. 1990), Patagonia (Donázar et al. 1993), and a grassland-agricultural ecosystem in Argentina (Leveau and Leveau 2002). The distribution of raptors across central Argentina was surveyed east to west from Buenos Aires

to Zapala, Neuquén (Travaini et al. 1995); we add to this body of knowledge and report results obtained from roadside raptor surveys carried out during December 1998 and January 1999 in the provinces of La Pampa, Córdoba, and San Luís.

STUDY AREA AND METHODS

Survey routes extended from Huanchilla, Córdoba in the north and Intendente Alvear, La Pampa in the east to the western border of La Pampa Province, approaching the Río Negro near the city of Neuquén in the province of Neuquén, Argentina (ca. 35°S, 64°W; Fig. 1). The climate becomes more arid from the eastern coast (Buenos Aires) to the mountains of western Argentina, with vegetation changing from agricultural grasslands to mesquite (*Prosopis* spp.) to desert-scrub grasslands. We chose four primary landscape divisions based on characteristics of the predominant vegetation type: agriculture, mixed agriculture/mesquite, mesquite, and desert-scrub grasslands.

The agriculture category consisted of a mix of cattle ranching and row-crop agriculture, with dominant summer crops of alfalfa, sunflower, sorghum, and corn. In the agricultural region, forests and shrubs exist intermittently, generally planted as shade areas for cattle, for wind breaks between fields, and as entrance corridors to estate houses. These forests most frequently consisted of groves of introduced eucalyptus (*Eucalyptus* spp.) trees. The mixed agriculture/mesquite category contained 25–75% mesquite, while the mesquite category contained

¹ Present address: USDA Forest Service, Chugach National Forest, 3301 C Street, Suite 300, Anchorage, AK 99503 U.S.A.; e-mail address: mgoldstein@fs.fed.us

² Present address: School of Animal, Plant and Environmental Sciences, University of the Witwatersrand, Private Bag 3, Wits 2050, South Africa.

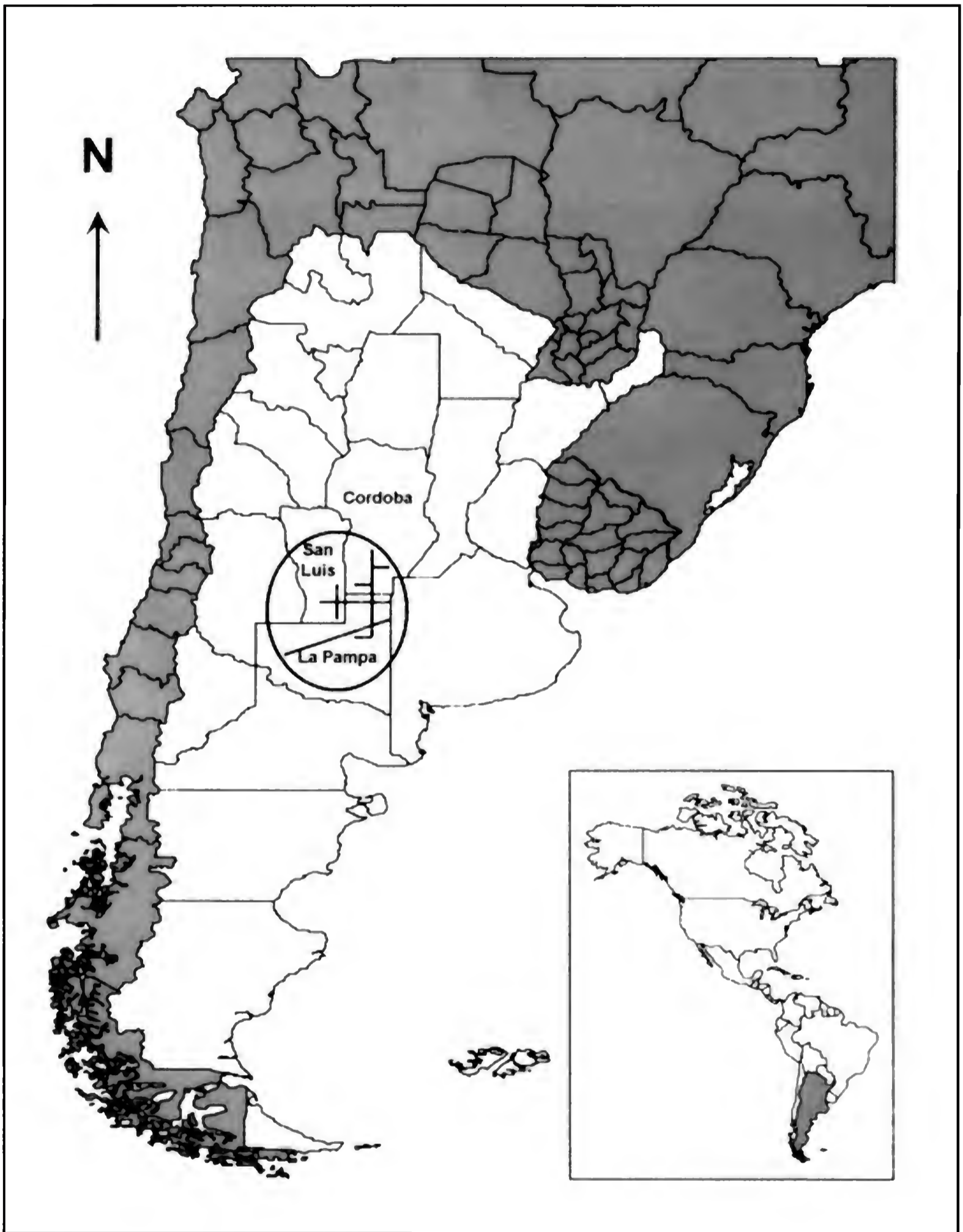


Figure 1. Map of roadside survey locations in the western pampas and central Argentina.

Table 1. Number of raptors observed in landscapes surveyed in the western pampas and central Argentina, December 1998–January 1999.

SPECIES	SCIENTIFIC NAMES	HABITAT TYPES				TOTAL
		AGRICULTURE	AGRICULTURE/ MESQUITE	MESQUITE	DESERT SCRUB	
American Kestrel	<i>Falco sparverius</i>	2	10	7	1	20
Aplomado Falcon	<i>Falco femoralis</i>	2	0	2	1	5
White-tailed Kite	<i>Elanus leucurus</i>	0	1	0	0	1
Chimango Caracara	<i>Milvago chimango</i>	292	138	38	22	490
Crested Caracara	<i>Caracara plancus</i>	42	48	63	19	172
Swainson's Hawk	<i>Buteo swainsoni</i>	36	1	0	0	37
Red-backed Hawk	<i>Buteo polyosoma</i>	1	1	1	3	6
White-tailed Hawk	<i>Buteo albicaudatus</i>	0	3	0	3	6
Burrowing Owl	<i>Athene cunicularia</i>	12	1	7	0	20
Short-eared Owl	<i>Asio flammeus</i>	1	1	0	0	2
Turkey Vulture	<i>Cathartes aura</i>	0	0	0	12	12
Black Vulture	<i>Coragyps atratus</i>	0	4	0	1	5
Richness		8	10	6	8	
Abundance		388	208	118	62	776
Richness/100 km		1.5	2.6	2.8	6.0	
Abundance/100 km		74.9	54.6	54.6	46.6	

>75% mesquite with small grassy patches scattered throughout. The desert-scrub grassland category contained <10% tree cover and generally consisted of natural grasslands.

We traveled survey routes between 0600–1100 H and 1630–2030 H (local time; on 1 January 1999 sunrise was at 0545 H and sunset at 2010 H). Surveys were completed on 32 routes over 16 d, with a minimum of 50 km and a maximum of 248 km per route. Each route was surveyed once to ensure bird sightings would be independent. The weather on survey days was partly cloudy to sunny with either no wind or a slight breeze. We recorded each occurrence of birds of prey and New World vultures in each habitat. We traveled on paved highways at approximately 80–90 km/hr, slightly faster than recommended (Fuller and Mosher 1987), but still at speeds at which we were able to detect species in different habitats, particularly the five common species analyzed for habitat selection.

To minimize differences in detectability among surveys, we standardized time of d, weather, driving speed, and number of observers (Fuller and Mosher 1987). In a few cases, we needed to stop the vehicle for positive identification; during these times we did not include new observations. Because of time and distance constraints, time in each habitat was not uniform.

We determined species richness and abundance by habitat type. We used curve-fitting software (CurveExpert©, 1995–2001; Daniel Hyams, Version 1.37) to demonstrate how richness increased with increasing number of km surveyed. CurveExpert© uses double-precision floating-point numbers to calculate and rank best-fit curves. In this manner, we describe the rate of species accumulations in each habitat type and include the correlation coefficient, r .

We analyzed habitat preference for the five species with

the greatest abundance (≥ 20 individuals) using a replicated goodness-of-fit test (Sokal and Rohlf 1995). We used replicated goodness-of-fit tests to determine whether raptors were distributed in proportion to available habitat, or whether individual raptor species deviated from the expected proportions in the same fashion (i.e., whether G for the pooled data, G_p , and G for the heterogeneity, G_H , were significant. We did not analyze species with low abundance (<20 observations).

RESULTS

We traveled 518 km through agricultural habitat, 381 km through the mixed agriculture/mesquite habitat, 216 km through pure mesquite habitat, and 133 km through desert-scrub grasslands. We counted 12 species of raptors and vultures totaling 776 individuals (Table 1). Agricultural lands had the lowest relative richness and highest relative abundance (1.5 species/100 km, 74.9 individuals/100 km), while desert scrub had the highest relative richness and lowest relative abundance (6.0 species/100 km, 46.6 individuals/100 km; Table 1). The raptor observations for the four habitat types were determined to have the following species accumulation curves (Fig. 2): the MMF model (Morgan et al. 1975) for agriculture ($y = [ab + cx^d]/[b + x^d]$; $a = -8.78$; $b = 0.90$; $c = 11.03$; $d = 0.29$; $SE = 0.45$; $r = 0.99$); the logistic model for mixed agriculture/mesquite ($y = a/(1 + b \times e^{-cx})$; $a = 9.51$; $b = 4.07$; $c = 0.038$; $SE = 0.79$; $r = 0.97$); the Power Fit for mesquite ($y = ax^b$; $a = 0.14$; $b = 0.68$; $SE = 0.92$; $r = 0.94$); and the rational function model for desert-scrub grasslands ($y = (a + bx)/(1 + cx + dx^2)$; $a = 0.23$; $b = 0.83$; $c = 0.11$; $d = -0.0001$; $SE = 0.26$; $r = 0.99$).

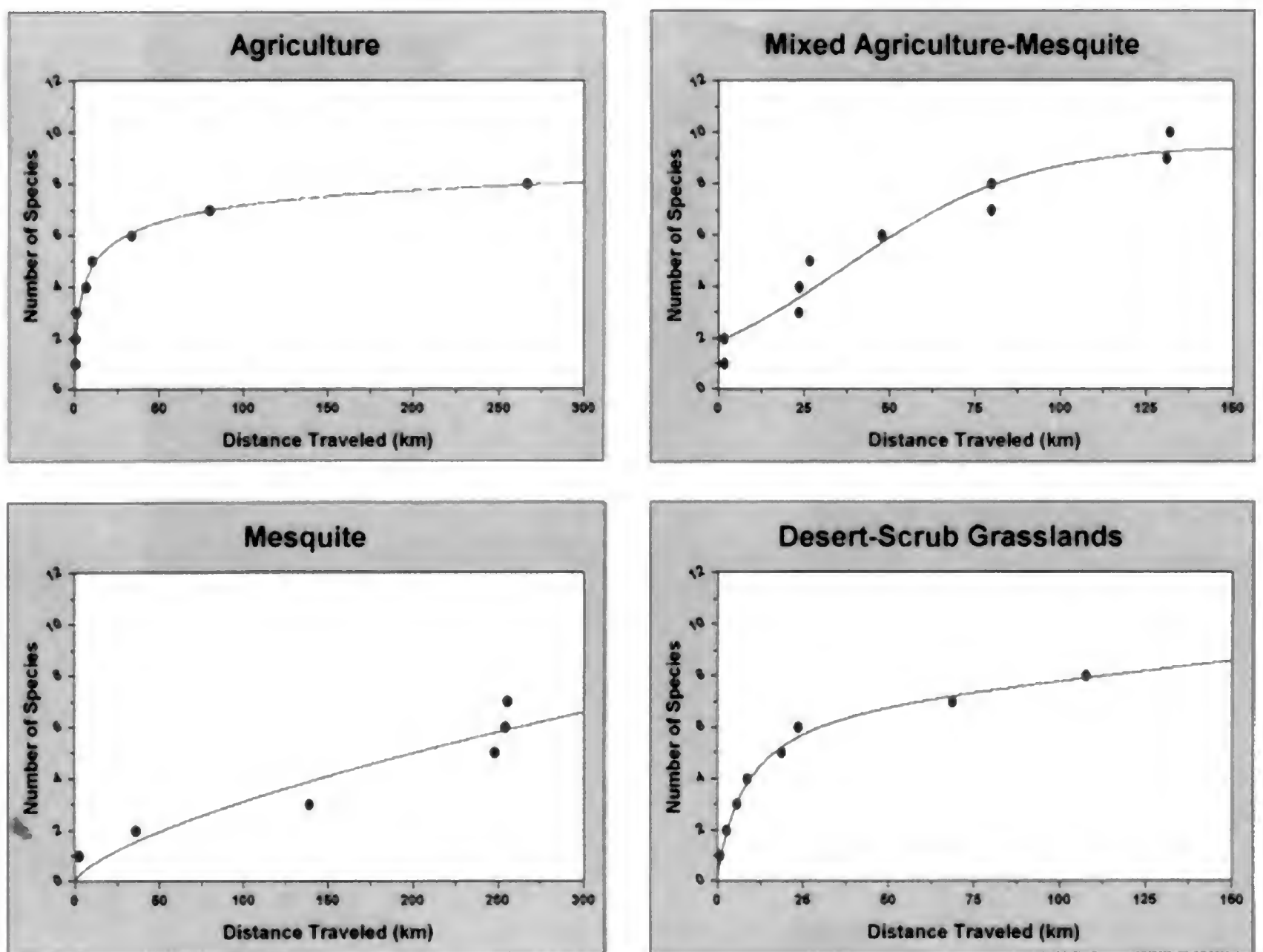


Figure 2. Species accumulation curves for raptors encountered during roadside surveys of four habitat types in Argentina.

Of the 12 species observed, we recorded 7 infrequently: Aplomado Falcon (*Falco femoralis*), White-tailed Kite (*Elanus leucurus*), Red-backed Hawk (*Buteo polyosoma*), White-tailed Hawk (*B. albicaudatus*), Short-eared Owl (*Asio flammeus*), Turkey Vulture (*Cathartes aura*), and Black Vulture (*Coragyps atratus*). Chimango Caracaras (*Milvago chimango*), Crested Caracaras (*Caracara plancus*), American Kestrels (*F. sparverius*), migratory Swainson's Hawks (*B. swainsoni*), and Burrowing Owls (*Athene cunicularia*) were most common. Chimango Caracaras ($N = 490$) were most frequently found in agriculture or mixed agriculture/mesquite and Crested Caracaras ($N = 172$) were most frequently found in mesquite. These two species occurred in all habitats and accounted for 85% of the total number of individuals sighted. American Kestrels ($N = 20$) were recorded infrequently, but also occurred in all surveyed habitats (Table 1). Swainson's Hawks and Burrowing Owls were found most commonly in agriculture. We often found Chimango Caracaras, Crested Caracaras, and Swainson's Hawks in groups (Table 2).

A replicated goodness-of-fit test on the five most common species indicated that raptors were not distributed in proportion to available habitat. The pooled goodness-of-fit test ($G_p = 43.8$; $df = 2$; $P < 0.001$) indicated that the raptor community as a whole was observed in habitats in proportions different from those available. In particular, raptor abundance in agricultural lands exceeded the proportion of available habitat. The heterogeneity goodness-of-fit test ($G_H = 173.1$; $df = 12$; $P < 0.001$) indicated that individual raptor species did not all deviate from the expected proportions in the same fashion. All individual goodness-of-fit tests also were significant (Table 3). American Kestrels used mesquite and agriculture/mesquite habitats, Crested Caracaras used mesquite, and Burrowing Owls used agriculture or mesquite. Both Chimango Caracaras and Swainson's Hawks were observed largely on agricultural lands.

DISCUSSION

Our results show that the five most commonly encountered species chose habitats differently and not in pro-

Table 2. Group sizes of species observed on roadside surveys.

NO. INDIVIDUALS	1	2	3	4	5	6-10	>10
Species							
American Kestrel	16	2					
Aplomado Falcon	1	2					
Chimango Caracara	200	61	17	7	7	4	2
Crested Caracara	81	22	7	4		1	
Swainson's Hawk	1	1				1	2
Red-backed Hawk	6						
White-tailed Hawk	2	2					
Burrowing Owl	6	2		1			
Turkey Vulture	8	2					
Black Vulture	2		3				

portion to their availability. Chimango Caracaras were more abundant than other species we encountered, similar to findings from other roadside surveys in Argentina. Chimango Caracaras accounted for 54% of all observations in Patagonia (Donázar et al. 1993) and 74% of all raptors surveyed in central Argentina (Travaini et al. 1995). Chimango Caracaras, a poorly studied yet common species, use agricultural areas extensively. This species is often found near trees, foraging on snakes, rodents, birds, and insects, depredating nestlings and eggs, eating roadkills, other carrion, and refuse near houses (M. Goldstein unpubl. data). Previous studies, like cur-

rent findings, associate Swainson's Hawks with agricultural lands in Argentina, where they forage opportunistically on swarms of grasshoppers (Jaramillo 1993, Goldstein et al. 1999). Opportunistic feeders that forage in groups often are found in association with agricultural fields and rangelands (Ellis et al. 1990, Eakle 1994).

Smaller falcons may be more difficult to detect than larger birds, particularly while completing roadside surveys at fast speeds. Similarly, our ability to detect falcons may change with habitat type. Detectability of small perching falcons may be reduced with dense habitat structure (Fuller and Mosher 1987). Aplomado Falcons

Table 3. Replicated goodness-of-fit test of habitat selection for the five most common raptor species encountered on road surveys in the western pampas and central Argentina. Species numbers are followed by percent observed in parentheses.

SPECIES km	AGRICULTURE	AGRICULTURE/ MESQUITE	MESQUITE	DESERT SCRUB	TOTAL	G
	518 (41.5%)	381 (30.5%)	216 (17.3%)	133 (10.7%)	1248	
American Kestrel	2 (10%)	10 (50%)	7 (35%)	1 (5%)	20	12.5*
Burrowing Owl	12 (60%)	1 (5%)	7 (35%)	0	20	15.1*
Chimango Caracara	292 (60%)	138 (28%)	38 (8%)	22 (4%)	490	90.1*
Crested Caracara	42 (24%)	48 (28%)	63 (37%)	19 (11%)	172	42.7*
Swainson's Hawk	36 (97%)	1 (3%)	0	0	37	56.5*
Total	384 (52.0%)	198 (26.8%)	115 (15.6%)	42 (5.7%)	739	

$$G_H = 173.1^*$$

$$G_P = 43.8^*$$

$$G_T^a = 216.9^*$$

^a $G_T = G_H + G_P$

* Significant at $\alpha < 0.001$.

and American Kestrels perched on fence posts and barbed wires may stand out more than when perched on trees in forested habitats, which may have led to undercounting in the latter. However, electrical and phone wires did not exist across the entire sample area. There were no wires in the desert scrub habitat and wires were intermittent across other regions. In the two habitats with greater tree structure, mixed agriculture/mesquite and mesquite, we detected more kestrels. In a 35-km section of road with electrical wires, through mixed agricultural and mesquite habitat, we detected six American Kestrels on wires. Although we noted no other landscape differences (e.g., ridges or valleys), we do not know whether American Kestrels were more visible on this section of road, wires influenced their visibility, or they simply had greater abundance in this area.

Relative richness was inversely correlated with the number of km traveled. Although we observed the greatest relative richness in desert-scrub habitat and the lowest relative richness in agriculture, this dichotomy may have been due to unit effort (Heyer et al. 1994). In other words, if the rapid species accumulations we found in these two habitats were equivocal, then relative richness was a function of sampling effort and we over-estimated its value. Nonetheless, our results indicate that common raptors exhibited distinct landscape preferences, and for the two most common species, Chimango and Crested caracaras, it was likely a result of greater foraging opportunities in disturbed landscapes.

RESUMEN.—Contamos 776 rapaces y buitres a lo largo de estudios al borde de carretera que totalizaron 1248 km durante diciembre de 1998 y Enero de 1999. Viajamos 518 km a través de hábitats agrícolas, 381 km a través de un hábitat arbustivo mixto de cultivos agrícolas y mesquite (*Prosopis* spp.), 216 km a través de hábitat de puro mesquite, y 133 km a través de desierto arbustivo en las pampas occidentales y el centro de Argentina. De las 10 especies observadas, los caracaras chimango (*Milvago chimango*) y los Caracaras crestados (*Caracara plancus*) ocurrieron a lo largo de todas las rutas estudiadas en todos los hábitats y fueron los más comunes. Las tierras agrícolas tuvieron la más baja riqueza relativa y la más alta abundancia relativa, mientras que el desierto arbustivo tuvo la más alta riqueza relativa y la más baja abundancia relativa. Un test replicado de bondad de ajuste para las cinco especies más comunes indicó que las especies no estuvieron distribuidas en proporción al hábitat disponible ($G_p = 43.8$; $P < 0.001$) y diferentes especies mostraron preferencia por diferentes hábitats.

[Traducción de César Márquez]

ACKNOWLEDGMENTS

We thank A. Lanusse and M. Bechard for logistical support and field assistance while in La Pampa. T. Lacher, M. Corson, K. Kosciuch, J.J. Negro, M. Carrete, and an

anonymous reviewer provided critical input for earlier versions of the manuscript.

LITERATURE CITED

- CADE, T.J. 1969. The status of the peregrine and other Falconiformes in Africa. Pages 289–321 in J.J. Hickey [Ed.], Peregrine Falcon populations: their biology and decline. Univ. Wisconsin Press, Madison, WI U.S.A.
- DONÁZAR, J.A., O. CEBALLOS, A. TRAVAINI, AND F. HIRALDO. 1993. Roadside raptor surveys in the Argentinean Patagonia. *J. Raptor Res.* 27:106–110.
- EAKLE, W.L. 1994. A raptor roadside survey in western Turkey and Eastern Greece. *J. Raptor Res.* 28:186–191.
- ELLIS, D.H., R.L. GLINSKI, AND D.G. SMITH. 1990. Raptor road surveys in South America. *J. Raptor Res.* 24:98–106.
- FULLER, M.R. AND J.A. MOSHER. 1987. Raptor survey techniques. Pages 37–65 in B. Giron-Pendleton, B. Millsap, K. Cline, and D. Bird [Eds.], Raptor management techniques manual. Natl. Wildl. Fed., Washington, DC U.S.A.
- GOLDSTEIN, M.I., T.E. LACHER, JR., B. WOODBRIDGE, M.J. BECHARD, S.B. CANAVELLI, M.E. ZACCAGNINI, G.P. COBB, E.J. SCOLLON, R. TRIBOLET, AND M.J. HOOPER. 1999. Monocrotophos-induced mass mortality of Swainson's Hawks in Argentina, 1995–96. *Ecotox.* 8: 201–214.
- HEYER, W.R., M.A. DONNELLY, R.W. MCDIARMID, L.C. HAYEK, AND M.S. FOSTER. 1994. Measuring and monitoring biological diversity: standard methods for amphibians. Smithsonian Institution Press, Washington, DC U.S.A.
- JARAMILLO, A.P. 1993. Wintering Swainson's Hawks in Argentina: food and age segregation. *Condor* 95:475–479.
- LEVEAU, L.M. AND C.M. LEVEAU. 2002. Uso de hábitat por aves rapaces en un agroecosistema pampeano. *Hornero* 17:9–15.
- MEYBURG, B.-U. 1973. Observations sur l'abondance relative des rapaces (Falconiformes) dans le nord et l'ouest de l'Espagne. *Ardeola* 19:129–150.
- MORGAN, P.H., L.P. MERCER, AND N.W. FLODIN. 1975. General model for nutritional responses of higher organisms. *Proc. Natl. Acad. Sci.* 72:4327–4331.
- SOKAL, R.R. AND F.J. ROHLF. 1995. Biometry, 3rd Ed. W.H. Freeman, NY U.S.A.
- TRAVAINI, A., A. RODRÍGUEZ, O. CEBALLOS, J.A. DONÁZAR, AND F. HIRALDO. 1995. Roadside raptor surveys in central Argentina. *Hornero* 14:64–66.
- WOFFINDEN, N.D. AND J.R. MURPHY. 1977. A roadside raptor census in the eastern Great Basin 1973–74. *Raptor Res.* 11:62–66.

Received 3 February 2003; accepted 30 November 2003
Associate Editor: Juan José Negro

J. Raptor Res. 38(2):158–160

© 2004 The Raptor Research Foundation, Inc.

PEREGRINE FALCONS NESTING ON LAKE BLUFFS ON THE ARCTIC COASTAL PLAIN OF NORTHERN ALASKA

ROBERT J. RITCHIE¹ AND ANN M. WILDMAN

ABR, Inc.—Environmental Research & Services, P.O. Box 80410, Fairbanks, AK 99708 U.S.A.

CLAYTON M. WHITE

Department of Integrative Biology, Brigham Young University, Provo, UT 84602 U.S.A.

KEY WORDS: *Peregrine Falcon; Falco peregrinus; Arctic, survey, habitat; Alaska.*

Historically, surveys of birds throughout Alaska have demonstrated clearly that the Peregrine Falcon (*Falco peregrinus*) has a dendritic pattern in its breeding distribution because it nested along coastlines or rivers (e.g., Cade 1960). The best examples of this are the shoreline nest sites on the Aleutian Islands (*F. p. pealei*), and along the large rivers of Alaska, such as the Yukon, Tanana, and Colville, and their tributaries (*F. p. anatum* and *tundrius*), but not at isolated montane cliffs away from shorelines and rivers. However, a few isolated cases of nesting by *anatum* on cliffs near lakes and in upland areas have been reported in interior Alaska. In the lower Kuskokwim River region, cliffs at two lakes were defended by peregrines in late July (Mindell 1983). Also, cliffs near Tetlin Lake (AK Department of Fish and Game unpubl. data) and at Lake Minchumina (D. Bishop pers. comm.) were occupied by peregrines. An adult male with a brood patch was collected on Lake Minchumina in 1955 (C. White unpubl. data). A pair, possibly nesting, was observed on a cliff at Lake Grosvernor on the Alaska Peninsula (Cahalane 1959). However, no nest sites have been recorded at lakes in northern Alaska, the range of *F. p. tundrius*.

In 1999, while conducting fixed-wing aerial surveys for raptors primarily along rivers in the National Petroleum Reserve–Alaska (NPR–A) on the Arctic Slope of Alaska, we encountered Peregrine Falcons on mud bluffs at four large lakes (e.g., Fig. 1a; Ritchie and Wildman 2000). Pairs and young were observed at two of these bluffs. A single adult was seen defending an apparent nest site at another lake bluff, where young may have been obscured by vegetation. A single adult also was perched near a ledge on a similar soil bluff at a fourth lake. Each sighting occurred on shoreline banks of large lakes in the Oumalik Lakes region of the southern portion of the Arctic Coastal Plain in the NPR–A (Gallant et al. 1995). All sites were located between 69°35'N and 69°55'N latitude, and 154°50'W and 155°30'W longitude. At least another 10

lakes with similar shoreline features in this area were checked from the aircraft, but no sign of peregrines was detected at those sites. Our assessment of use of this type of habitat by nesting peregrines was limited because only a few lakes adjacent to our riparian routes were surveyed and because fixed-wing surveys rarely detect all peregrine pairs. For example, sites occupied by failed breeders may have been missed because our surveys were timed to maximize observations of successful nests with large, conspicuous young.

The four bluffs where peregrines were observed were 5–12 m high (e.g., Fig. 1b), and falcons at the three sites with young or probable young defended ledges located 4–10 m from the shoreline. Vegetation included low shrubs (*Salix* sp.) that generally shaded or overhung each ledge. The nest ledges were formed by eroding shorelines that created a jumble of dirt blocks with cracks and ledges interspersed. All sites were on southern or southwestern exposures and were 1.5–2.5 km from the nearest riparian area. Also these sites with peregrines were on deep, open lakes with little emergent vegetation. Surrounding habitats included wet non-patterned (i.e., more homogeneous surface form) tundra, drier upland tussock tundra, and sand dunes and willow banks associated with lacustrine and stream shorelines in this area.

The use of lacustrine habitats for nesting has not been previously recorded for *tundrius* in northern Alaska. However, there are records elsewhere in the arctic range of Peregrine Falcons. In a description of 29 sites used by nesting *tundrius* peregrines in Rankin Inlet, Northwest Territories, Canada, all were within 300 m of substantial waterbodies (i.e., the ocean for most nest sites), including five sites on the mainland (Court et al. 1988). Some of these inland sites overlooked small lakes (G. Court pers. comm.). In Eurasian regions, such as Scandinavia and the Baltic countries, peregrines commonly nest on the shores of small lakes and in bogs (Kumari 1974, Lindberg et al. 1988). Finally, peregrines were found to nest on “clayish or sandy precipices of the cliffs of rivers and large lakes” on the west Taimyr Peninsula, Russia (Krechmar 1966).

There are a number of explanations for why nesting pairs have not been identified earlier at lakes in northern

¹ E-mail address: britchie@abrinc.com

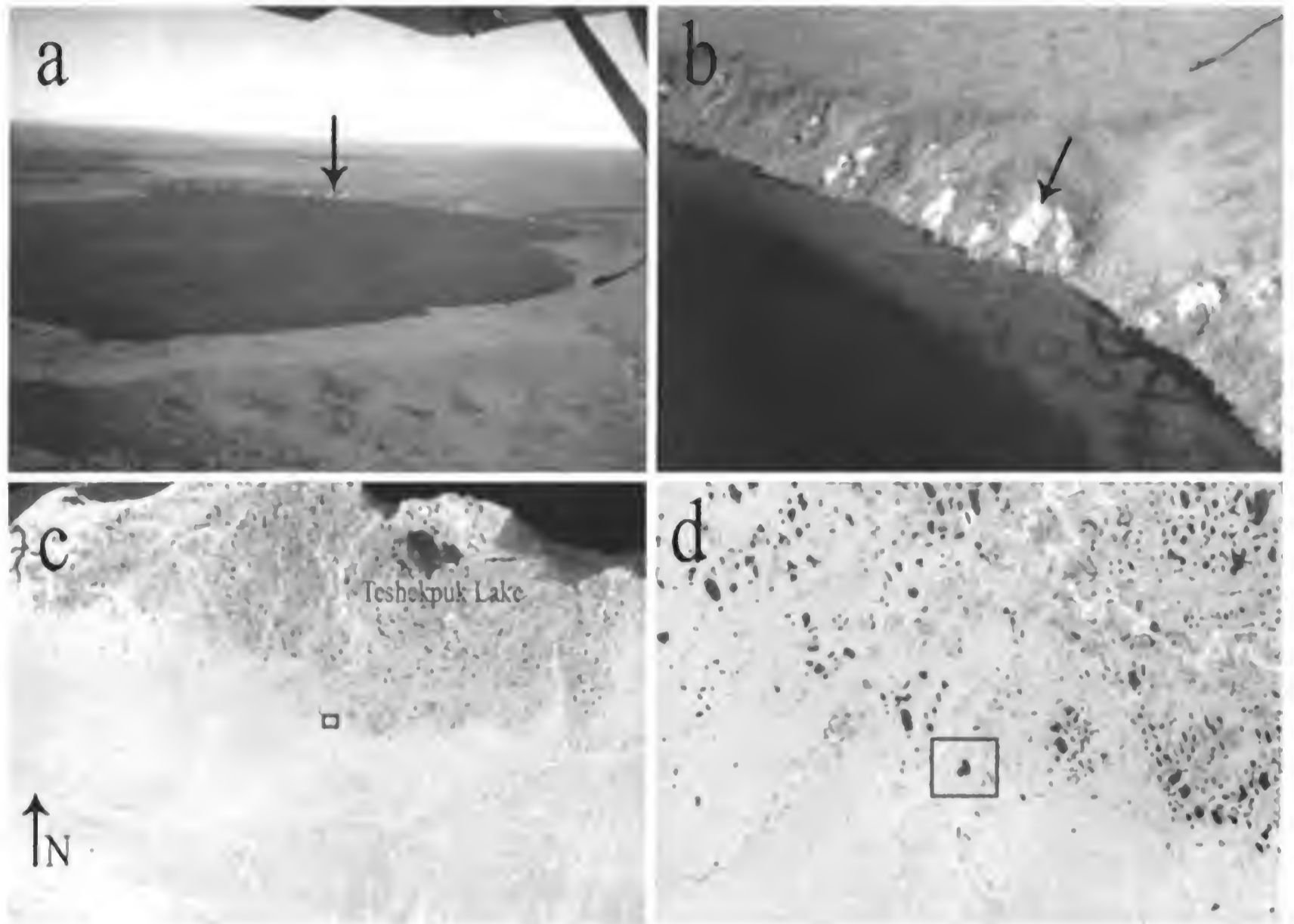


Figure 1. Aerial views of lake habitats on the Arctic Coastal Plain, Alaska: (a) example of a deep open lake used by Peregrine Falcons; (b) ca. nest site of a Peregrine Falcon on lake bluff; (c) general distribution of lakes in a sample of Coastal Plain-Foothill regions transition, which could be suitable habitat for nesting peregrines; and (d) closer view of suitable lakes for Peregrine Falcon nesting. Arrows denote nest-site locations and squares indicate lakes occupied by adult peregrines.

Alaska. First, lakes historically have not been searched regularly during raptor cliff-nesting surveys along rivers on Alaska's Arctic Slope (ca. 1950–99), where most *tundra* habitat was thought to occur and where known nest sites were found. Instead, major surveys to monitor peregrine populations in northern Alaska primarily were confined to boat surveys of cliffs along rivers (e.g., Ambrose et al. 1988), with a few helicopter and fixed-wing aircraft surveys in more remote drainages (e.g., Cade and White 1976).

Second, Peregrine Falcon numbers were depressed during the 1950s–70s when the region received the greatest attention by biologists interested in the region because of the species' status and oil exploration (e.g., Haugh 1970, White and Streater 1970, Cade and White 1976, and Ambrose et al. 1988). Without a previous history of use of lake shorelines, lakes were not visited during these surveys.

A third explanation may be the expansion of this re-

covering population into "lower-quality" sites that have habitat features similar to adjacent riparian areas that are currently occupied by high densities of peregrines (e.g., Ikpikpuk River; R. Ritchie unpubl. data). As traditional areas have become more "saturated" with birds, lower-quality or less-preferred sites with similar features (e.g., substrate, prey abundance) have become occupied. There also are increasing numbers of sites, once believed marginal for nesting peregrines that are adjacent to traditional habitats, that now are occupied by peregrines in arctic and interior Alaska: man-made sites (e.g., telecommunication towers), highway banks, and quarries (e.g., Ritchie et al. 1998).

A quick assessment of aerial photography of the Arctic Coastal Plain and Foothills regions shows that numerous lakes (Fig. 1c, d), particularly at the southern extent of the Arctic Coastal Plain, may have suitable-habitat features (i.e., southern exposures, eroding banks, proximity to riparian nesting areas) and provide nesting opportu-

nities for Peregrine Falcons. Deep open lakes in the Arctic Foothills, or at least a transition area between the Arctic Coastal Plain and Foothills regions, also may be suitable for nesting peregrines. Indeed, an aggressive pair of Peregrine Falcons was observed near "white-washed ledges" along a shoreline of a lake between the Itkillik and Kuparuk rivers, >150 km southeast from the sites described above (S. Murphy pers. comm.). We recommend that future surveys and monitoring activities to identify Peregrine Falcons nesting in northern Alaska be modified to include large, deep lakes, particularly those in the Arctic Foothills Region and in the transition area between the Arctic Coastal Plain and Foothills regions. Further, with increasing industrial development in northern Alaska, surveys may also be warranted to assess possible strategies for protection of this raptor habitat.

RESUMEN.—Registramos la primera anidación de halcones peregrinos (*Falco peregrinus*) en peñascos de lagunas costeras en el norte de Alaska durante estudios aéreos de anidación en cornisas en 1999. Los halcones peregrinos fueron identificados en cuatro lagos en la región de lagos de Oumalik en el Plano Costero Artico. Al menos dos de estos registros incluyeron observaciones de polluelos de halcón. Acantilados bajos (5–12 m) con repisas numerosas formadas por la erosión de la línea costera, y expuestas predominantemente hacia el sur o suroccidente, caracterizan cada sitio. Los autores sintetizan la información sobre nidos lacustres en todo el rango norte del halcón peregrino. Las posibles explicaciones para este reciente descubrimiento incluyen un limitado historial de estudios en estas áreas, una población de halcones peregrinos deprimida cuando la actividad de estudios de rapaces en Alaska fue más intensa (1950s–70s), y con la recuperación de la especie, una expansión de la población del peregrino en sitios de "mas baja calidad" adyacentes a sitios con altas densidades de halcones peregrinos. La distribución y abundancia relativa de este tipo de hábitat en el norte de Alaska, y el potencial para el desarrollo industrial en esta región ameritan la identificación y aplicación de consideraciones para la conservación.

[Traducción de César Márquez]

ACKNOWLEDGMENTS

The Bureau of Land Management (BLM), Fairbanks, Alaska, provided funding for the aerial surveys described in this paper. Dave Yokel, BLM Wildlife Biologist, in particular, helped to secure funding and provided invaluable logistical support. We are grateful to Dr. Bob Day and John Shook of ABR, Inc., Environmental Research and Services, and two anonymous reviewers for The Journal of Raptor Research, who provided editorial comments on earlier drafts of this paper. Finally, without the safe and expert flying of Sandy Hamilton, Pilot, Arctic Air Alaska, this information would not have been collected.

LITERATURE CITED

- AMBROSE, R.E., R.J. RITCHIE, C.M. WHITE, P.F. SCHEMPF, T. SWEM, AND R. DITTRICK. 1988. Changes in the status of Peregrine Falcon populations in Alaska. Pages 73–82 in T.J. Cade, J.H. Enderson, C.G. Thelander, and C.M. White [EDS.], *Peregrine Falcon populations their management and recovery*. The Peregrine Fund, Boise, ID U.S.A.
- CADE, T.J. 1960. Ecology of the peregrine and gyrfalcon populations in Alaska. *Univ. Calif. Publ. Zool.* 63:151–290.
- AND C.M. WHITE. 1976. Colville River watershed. Pages 245–48 in R.W. Fyfe, S.A. Temple, and T.J. Cade [EDS.], *The 1975 North American Peregrine Falcon survey*. *Can. Field-Nat.* 90:228–273.
- CAHALANE, V.H. 1959. A biological survey of the Katmai National Monument. *Smithson. Misc. Collect.* 138:1–246.
- COURT, G.S., C.C. GATES, AND D.A. BOAG. 1988. Natural history of the Peregrine Falcon in the Keewatin District of the Northwest Territories. *Arctic* 41:17–30.
- GALLANT, A.L., E.F. BINNIAN, J.M. OMERNIK, AND M.B. SHASBY. 1995. *Ecoregions of Alaska*. U.S. Geol. Surv. Prof. Paper 1567, Washington, DC U.S.A.
- HAUGH, J.R. 1970. Northern Alaska. Pages 243–244 in T.J. Cade and R. Fyfe [EDS.], *The North American peregrine survey, 1970*. *Can. Field-Nat.* 84:231–245.
- KRECHMAR, A.V. 1966. Ptitsy Zapadnogo Taimyra. *Proc. Zool. Inst. Acad. Sci. USSR.* 39:185–312.
- KUMARI, E. 1974. Past and present of the Peregrine Falcon in Estonia. Pages 230–253 in E. Kumari [ED.], *Estonian wetlands and their life*. Acad. Sci. Estonia, "Valgus," Tallinn, Estonia.
- LINDBERG, P., P.J. SCHEI, AND M. WIKMAN. 1988. The Peregrine Falcon in Fennoscandia. Pages 159–172 in T.J. Cade, J.H. Enderson, C.G. Thelander, and C.M. White [EDS.], *Peregrine Falcon populations: their management and recovery*. The Peregrine Fund, Boise, ID U.S.A.
- MINDELL, D.P. 1983. Nesting raptors in southwestern Alaska: status, distribution, and aspects of biology. U.S. Bureau of Land Manage. Alaska Tech. Rpt. 8., Anchorage, AK U.S.A.
- RITCHIE, R.J. AND A.M. WILDMAN. 2000. Aerial surveys of cliff-nesting raptors in the National Petroleum Reserve–Alaska [NPR–A], 1999. ABR, Inc., Fairbanks, AK U.S.A.
- RITCHIE, R.J., T. DOYLE, AND J. WRIGHT. 1998. Peregrine Falcons (*Falco peregrinus*) nest in a quarry and on highway cutbanks in Alaska. *J. Raptor Res.* 32:261–264.
- WHITE, C.M. AND J.H. STREATER. 1970. The oil pipeline and peregrines in Alaska. Page 241 in T.J. Cade and R. Fyfe [EDS.], *The North American peregrine survey, 1970*. *Can. Field-Nat.* 84:231–245.

Received 28 January 2003; accepted 28 November 2003
Associate Editor: Ian G. Warkentin

J. Raptor Res. 38(2):161–163

© 2004 The Raptor Research Foundation, Inc.

UNUSUAL NESTING OF THE LESSER KESTREL (*FALCO NAUMANNI*) IN THESSALY, GREECE

CHRISTOS VLACHOS,¹ DIMITRIS BAKALOUDIS, AND EVANGELOS CHATZINIKOS

Aristotle University of Thessaloniki, Department of Forestry and Natural Environment, Laboratory of Wildlife and Freshwater Fisheries, P.O. Box 241, 54006 Thessaloniki, Greece

KEY WORDS: *Lesser Kestrel*; *Falco naumanni*; *breeding success*; *fledglings*; *nesting*.

The Lesser Kestrel (*Falco naumanni*) is a small falcon that breeds colonially and nests mainly in walls or roofs of houses, stables, barns, castles or churches, as well as in tree holes, earth cliffs, and in rocky outcrops (Cramp and Simmons 1980). Although the species was considered to be one of the most abundant European birds of prey, it has suffered from a massive population decline in large parts of its western Palearctic range between the 1960s and 1980s (Cramp and Simmons 1980, Biber 1996), now is of global conservation concern (SPEC 1 category), and considered to be vulnerable in Europe (Hagemeijer and Blair 1997). The reasons for the dramatic decline include the reduction of favorable nesting habitats (restoration and demolition of old buildings), and the intensification of agricultural practices (destruction and loss of foraging areas, and the reduction of prey availability; Donazar et al. 1993, Forero et al. 1996, Tella et al. 1998).

The trend of the Greek population, which comprises ca. 14–15% of the European total, has been similar. In Greece, the Lesser Kestrel shows a discontinuous distribution and now it is mainly concentrated in Thessaly, where Hallmann (1996) in a preliminary report recorded 104 colonies and a total of 2679 pairs.

The objectives of the present study were to estimate the breeding success of Lesser Kestrels nesting on the ground and in a fowl-run with hens and to compare these estimates to those of other colonies.

STUDY AREA AND METHODS

Megalo Monastiri is a small village at the southeastern part of the Larisa plain, central Greece. The village is situated on the edge of a hilly terrain, surrounded by grasslands and agricultural land, where the dominant crops are cereals and cotton, with small areas of almond trees. The altitude ranges from 50–120 m above sea level. The climate is thermo-mediterranean, with a mild rainy winter and a dry and hot summer. The mean annual precipitation is about 465 mm concentrated during the winter.

We located and monitored nests from March–September 1999. Most (75%) of the nests were found during the incubation period, while the rest were found at the be-

ginning of the egg-laying stage. Nests' contents were checked every 15 d to record possible reproductive failures, but in three periods they were checked more frequently: (1) during the beginning of incubation to assess clutch size; (2) just after hatching to estimate hatching success, brood size at hatching, and date of hatching; and (3) during fledging to record the number of young fledged (Steenhof 1987). A pair which laid eggs was defined as a reproductive pair, a successfully-breeding pair was one that fledged at least one young, and breeding success was defined as the percentage of successful territorial pairs (Newton 1979, Steenhof 1987). Means \pm SE are presented in the text and differences (using the Mann-Whitney *U*-test and the Fisher's Exact test for 2×2 tables) considered significant at $\alpha = 0.05$.

RESULTS AND DISCUSSION

A colony of 18 Lesser Kestrel breeding pairs, in an old building in Megalo Monastiri village was recorded in 1998. The next yr, the local municipality demolished the old building and cleared away most of the debris because it was dangerous for the people living in the area. Early in the next breeding season, the same numbers of Lesser Kestrel pairs were recorded at the location of the old building, as most of adult Lesser Kestrels show high fidelity to their breeding colonies (Serrano et al. 2001). We recorded a total of eight breeding attempts of Lesser Kestrels nesting on the ground, 75% of which were successful. Although ground-nesting behavior had not been observed before, the overall breeding success for these Lesser Kestrels was slightly higher than that recorded for the entire population in Megalo Monastiri in 1999 (69.7%, $N = 33$ pairs), but this difference was not significant (Fisher's Exact test, $P = 0.569$; Bakaloudis et al. 2000).

There were no significant differences in any reproductive parameter between the colony that nested on the ground and the population that nested on the buildings of the village. The mean clutch size was 3.1 ± 0.35 eggs, similar to the population in the village (3.5 ± 0.22 ; Mann-Whitney *U*-test, $P = 0.288$). Eighty-four percent of 25 laid eggs on the ground hatched successfully, resulting in a mean brood size at hatching of 2.6 ± 0.26 , which was similar to the mean brood size for the pairs nesting on buildings (3.1 ± 0.19 , $N = 26$; Mann-Whitney *U*-test, $P = 0.143$). Two of four unhatched eggs disappeared about 14 d after the incubation had begun. In both cases large eggshell fragments were found and we suspect that

¹ E-mail: cvlachos@for.auth.gr

domestic cats (*Felis catus*) and rats (*Rattus rattus*) were responsible for destroying those eggs. The mean brood size at fledging per successful pair was lower in the pairs nesting on the ground (2.67 ± 0.33 , $N = 6$) than the pairs nesting in buildings (3.09 ± 0.2 , $N = 23$), but not significantly so (Mann-Whitney *U*-test, $P = 0.371$). The mean number of young fledged per reproductive pair that nested on the ground was 2.00 ± 0.5 ($N = 8$) and did not differ from the mean number of kestrels reared by pairs that nested on the buildings (2.15 ± 0.29 , $N = 33$; Mann-Whitney *U*-test, $P = 0.771$). Seventy-six percent of 21 hatched eggs on the ground produced fledglings successfully. Most chick mortality (80%) occurred when the adults deserted the nests about 20 d after hatching. Although there was indication of the cause of those losses, which could be due either to an accident to their parents or to poor parental care, the feathered chicks in two broods (pairs D and H) died from starvation. In another case (pair C), the predated downy chick was found close to the nest with its siblings and had probably been killed by a rat. No evidence of cannibalism was observed in the colony of Lesser Kestrel on the ground, as was reported by Negro et al. (1992) for other colonies in Spain. The proportion of nests failing during incubation was lower than pairs nesting on the ground than nesting on buildings (58.3%, $N = 7$). Conversely, broods in nests on the ground (25%, $N = 3$) were more likely to fail than those in buildings (16.7%, $N = 2$; Fisher's Exact test, $P = 0.045$). This was due mainly to the higher predation pressure during the nestling stage on pairs nesting on the ground.

In general, breeding parameters of the Lesser Kestrel colony on the ground were similar to that of other populations, except for clutch size, which was lower than in other studies. Variations in clutch size and breeding success were also reported for other Lesser Kestrel populations (Negro and Hiraldo 1993, Tella et al. 1996) and may be related to changes in food availability from yr to yr or to habitat type (Newton 1979, Negro et al. 1992, Negro and Hiraldo 1993, Tella et al. 1996). The Lesser Kestrel that we studied fed exclusively on insects, mainly crickets and grasshoppers (Orthoptera), the populations of which fluctuate from yr to yr in the study area. The low clutch size of Lesser Kestrels that either nested on the ground or on the buildings in 1999, suggests that the period of study was a yr of food shortage, compared to that recorded for the same study area in 2000 (Bakaloudis et al. 2000). Finally, the percentage of unhatched eggs was low and similar to the results of other studies (Negro et al. 1993), suggesting that the hatching success either of Lesser Kestrels that nested on ground or on buildings in Megalo Monastiri village was not negatively affected by contamination. However, the widespread use of pesticides in intensive cultivation could be a possible reason for adult deaths or for low feeding rates (i.e., the observed mortality of chicks due to starvation) as these could affect prey populations negatively during the late

stage of the nestling period. The fact that Lesser Kestrel relies heavily on prey species that inhabit intensively-cultivated land, might be a cause of concern for the future.

We also monitored the breeding success of five pairs found nesting in a fowl-run. The mean clutch size was 3.2 eggs (SE = 1.5), brood size 2.8 young (SE = 1.3), and breeding success 60%. Sixty-nine percent of 16 laid eggs hatched successfully and 91% percent of the hatched eggs produced fledglings ($N = 2$). Between one and three hen eggs were also found in each kestrel nest. Also, one nest was found in a plastic barrel with two eggs, but failed to produce young and another one in an oil barrel with two eggs, which fledged one young successfully.

In conclusion, we suggest that the unusual ground-nesting observed, as well as the nesting in fowl-runs and in barrels, may be associated with the lack of other suitable nesting sites (Forero et al. 1996), the relative absence of predators (Balfour 1955, Seago 1967, Piechocki 1982, Village 1990) at this site and by the high fidelity exhibited by adults to their breeding colonies (Serrano et al. 2001).

RESUMEN.—Presentamos información sobre 8 nidos de *Falco naumanni* que han hecho nido en el suelo debajo de los restos de un edificio antiguo demolido en Thessalia, Grecia Central en 1999. Las variables reproductivas como tamaño de puesta en el momento del vuelo (3.1 huevos puestos), el tamaño de pollada (2.6 pollos) y éxito reproductor (2.6 pollos) no tienen diferencias importantes comparados con los que han sido observados en instalaciones humanas en la misma región de estudio. En el 75% de los nidos se ha criado con éxito al menos un pollo, con un promedio de 2.0 pollos por pareja reproductora. Cinco parejas han sido localizadas en gallineros usando los mismos nidos de las gallinas y tres de ellos criaron pollos con éxito. Una puesta fue encontrada en un cubo de plástico y otra en un barril de aceite.

[Traducción de los autores]

ACKNOWLEDGMENTS

We would like to thank E. Vlachou, E. Dafos, V. Botzorlos, T. Papadopoulos, and D. Tsalagas for their assistance with the fieldwork. We are also grateful to the 4th Hunting Federation of Sterea Hellas and Municipal Enterprise and Ecotourist Center of Dadia, which have supported this research financially. We also thank Drs. J.J. Negro, D. Serrano, and an anonymous referee who reviewed and greatly improved this manuscript.

LITERATURE CITED

- BALFOUR, E. 1955. Kestrel nesting on the ground in Orkney. *Bird Notes* 26:245–253.
- BAKALOUDIS, D., C. VLACHOS, AND E. CHATZINIKOS. 2000. Breeding success in the Lesser Kestrel *Falco naumanni* in Thessaly, central Greece. Conference for Birds of Prey and Owls, 22–26 November 2000. Mikulov, Czech Republic.
- BIBER, J.P. 1996. International action plan for the Lesser

- Kestrel (*Falco naumanni*). Pages 191–203 in B. Heredia, L. Rose, and M. Painter [EDS.], Globally threatened birds in Europe. Council of Europe Publishing, Berlin, Germany.
- CRAMP, S. AND K.E.L. SIMMONS. 1980. The birds of the western palearctic. Vol. 2. Hawks to bustards. Oxford Univ. Press, Oxford, U.K.
- DONÁZAR, J.A., J.J. NEGRO, AND F. HIRALDO. 1993. Foraging habitat selection, land-use changes and population decline in the Lesser Kestrel *Falco naumanni*. *J. Applied Ecol.* 30:515–522.
- FORERO, M.G., J.L. TELLA, J.A. DONÁZAR, AND F. HIRALDO. 1996. Can interspecific competition and nest site availability explain the decrease of Lesser Kestrel *Falco naumanni* populations? *Biol. Conserv.* 78:289–293.
- HAGEMEIJER, W.J.M. AND M.J. BLAIR. 1997. The EBCC Atlas of European Breeding Birds: Their Distribution and Abundance. T. & A.D. Poyser, London, U.K.
- HALLMANN, B. 1996. Lesser Kestrel survey: Thessaly 1995. Report to the Hellenic Ornithological Society, Thessaloniki, Greece.
- NEGRO, J.J., J.A. DONÁZAR, AND F. HIRALDO. 1992. Kleptoparasitism and cannibalism in a colony of Lesser Kestrels (*Falco naumanni*). *J. Raptor Res.* 26:225–228.
- , J.A. DONÁZAR, F. HIRALDO, L. HERNÁNDEZ, AND M. FERNÁNDEZ. 1993. Organochlorine and heavy metal contamination in non-viable eggs and its relation to breeding success in a Spanish population of Lesser Kestrels (*Falco naumanni*). *Environ. Pollut.* 82:201–205.
- , AND F. HIRALDO. 1993. Nest-site selection and breeding success in the Lesser Kestrel *Falco naumanni*. *Bird Study* 40:115–119.
- NEWTON, I. 1979. Population ecology of raptors. T. & A. D. Poyser, London, U.K.
- PIECHOCKI, R. 1982. Der Turmfalke. Ziemsen-Verlag, Wittenberg, Germany.
- SEAGO, M.J. 1967. The birds of Norfolk. Jarrold & Son, Norwich, U.K.
- SERRANO, D., J.L. TELLA, M.G. FORERO, AND J.A. DONÁZAR. 2001. Factors affecting breeding dispersal in the facultatively colonial Lesser Kestrel: individual experience vs. conspecific cues. *J. Animal Ecol.* 70:568–578.
- STEENHOF, K. 1987. Assessing raptor reproductive success and productivity. Pages 157–170 in B.A.G. Pendleton, B.A. Millsap, K.W. Cline, and D.M. Bird [EDS.], Raptor management techniques manual. Nat. Wildl. Fed., Washington, DC U.S.A.
- TELLA, J., F. HIRALDO, J. DONÁZAR, AND J. NEGRO. 1996. Costs and benefits of urban nesting in the Lesser Kestrel. Pages 53–60 in D. Bird, D. Varland, and J.J. Negro [EDS.], Raptors in human landscapes. Academic Press Ltd., London, U.K.
- , M.G. FORERO, F. HIRALDO, AND J.A. DONÁZAR. 1998. Conflicts between Lesser Kestrel conservation and European agricultural policies as identified by habitat use analysis. *Conserv. Biol.* 12:593–604.
- VILLAGE, A. 1990. The kestrel. T. & A.D. Poyser, London, U.K.

Received 29 January 2003; accepted 29 December 2003
Associate Editor: Juan José Negro

J. Raptor Res. 38(2):163–168

© 2004 The Raptor Research Foundation, Inc.

FAT STORES OF MIGRANT SHARP-SHINNED AND COOPER'S HAWKS IN NEW MEXICO

JOHN P. DELONG¹

HawkWatch International, Inc., 1800 South West Temple, Suite 226, Salt Lake City, UT 84115 U.S.A. and Department of Biology, Utah State University, 5305 University Blvd., Logan, UT 84322 U.S.A.

STEPHEN W. HOFFMAN²

HawkWatch International, Inc., 1800 South West Temple, Suite 226, Salt Lake City, UT 84115 U.S.A.

KEY WORDS: *Cooper's Hawk*; *Accipiter cooperii*; *Sharp-shinned Hawk*; *Accipiter striatus*; *avian energetics*; *migration*; *fat scores*; *fat stores*.

¹ Present address: 2314 Hollywood Ave. NW, Albuquerque, NM 87104 U.S.A.; e-mail address: jpdelong@comcast.net

² Present address: Audubon Pennsylvania, 100 Wildwood Way, Harrisburg, PA 17110 U.S.A.

Birds use stored fats to supply energy during times when foraging is limited or not possible (King 1970, Blem 1980). During migration, stored fat allows birds to make uninterrupted flights between places and times when foraging can occur and fat stores can be replenished (King 1970, Blem 1980). The amount of fat that birds store during and leading up to migration varies widely (Blem 1980). Fat stores ranged from 4% of total body mass in Common Buzzards (*Buteo buteo vulpinus*) migrating through Israel (Gorney and Yom-Tov 1994) to

32% of total body mass in Pacific Golden-Plovers (*Pluvialis fulva*) preparing to cross the Pacific (Johnson et al. 1989). Presumably, the amount of fat stored is adaptive and relates to the amount of energy needed to fuel flights between predicted stopover sites where fat stores can be replenished (King 1970, Blem 1980, 1990). Although many studies have investigated fat stores in migrating songbirds and shorebirds (Blem 1980), only a few have examined the fat stores of migrating raptors (Gessaman 1979, Smith et al. 1986, Harden 1993, Gorney and Yom-Tov 1994).

Sharp-shinned (*Accipiter striatus*) and Cooper's hawks (*A. cooperii*) are medium-range-partial migrants often observed migrating along mountain ridges and coastlines across much of North America (Kerlinger 1989). We captured Sharp-shinned and Cooper's hawks during spring and fall migration in central New Mexico and used equations developed by DeLong and Gessaman (2001) to estimate their fat stores. In this paper, we describe fat stores in these migrating hawks and examine differences by migration season, species, age, and sex.

METHODS

We captured hawks at two sites in central New Mexico where HawkWatch International, Inc., conducts long-term raptor migration studies (Hoffman et al. 2002). The spring study site is located at the south end of the Sandia Mountains in the Cibola National Forest, ca. 18 km east of Albuquerque (35°05'N, 106°26'W). The spring banding season generally began on 10 March and lasted through late April, and we used data collected from 1994–96. The fall study site is located in the Manzano Mountains in the Cibola National Forest, ca. 56 km south-southeast of Albuquerque (34°42'N, 106°24'W) and 34 km south of the Sandia site. The fall banding season generally began on 1 September and lasted through late October, with peak flights occurring in late September and early October (DeLong and Hoffman 1999). We used data collected from 1992–96. Sharp-shinned and Cooper's hawks migrating through these sites are using the Rocky Mountain Flyway described in Hoffman et al. (2002). Birds captured at these sites appear to breed from New Mexico north to Alberta and winter primarily in southwestern Mexico (Hoffman et al. 2002).

We captured hawks as described in Hoffman et al. (2002). We used plumage characters to determine age (adult and immature; Mueller et al. 1979, 1981) and size to determine sex (Hoffman et al. 1990). We measured mass to the nearest 1 g (using an electronic balance) and tarsus length (Hoffman et al. 1990) to the nearest 0.1 mm (using calipers). We examined birds for the presence of food in their crop (esophageal pouch) and hereafter refer to "cropped" birds (with food detectable in the crop) and "uncropped" birds (with no food detectable). We assigned fat scores to birds using the subalar fat pad located under the wing on the bird's right side with the 4-point (0–3) classification system described in DeLong and Gessaman (2001). Scores were assigned as follows: 0 for birds with no visible fat, 1 for birds with a shallow streak of fat, 2 for birds with fat that was approximately flush with surrounding muscle tissue, and 3 for

birds with fat that exceeded the depth of the surrounding muscle tissue. Birds were released promptly after processing.

We estimated the fat stores for each bird using a model with body mass and tarsus length as predictor variables (DeLong and Gessaman 2001). These models were based on fat extraction techniques that allowed known fat stores to be regressed against structural size measurements and mass. The four models were specific to species and sex classes:

$$\ln(Y)_{\text{Cooper's Hawk, female}} = 3.1380 + 0.0149 \times M - 0.0881 \times T \quad (1)$$

$$\ln(Y)_{\text{Cooper's Hawk, male}} = 9.9095 + 0.0149 \times M - 0.1868 \times T \quad (2)$$

$$\ln(Y)_{\text{Sharp-shinned Hawk, female}} = -0.1362 + 0.0437 \times M - 0.0881 \times T \quad (3)$$

$$\ln(Y)_{\text{Sharp-shinned Hawk, male}} = 6.6353 + 0.0437 \times M - 0.1868 \times T \quad (4),$$

where M = mass in g, T = tarsus length in mm, and Y = fat stores in g. We took the antilog of the values produced by these equations (e to the power of the equation output) to get an estimate of the total grams of fat stored by each bird.

We limited our dataset in three ways. First, the estimated fat stores for migrating hawks produced by equations 1–4 exceeded the range of fat stores in the calibration sample (up to about 70 g fat in the calibration sample; DeLong and Gessaman 2001). Although the calibrated model was linear, we felt that only modest use of data beyond the calibration range was justified. An examination of a histogram of fat stores for migrants indicated that an appropriate upper cutoff to use in this study was a fat store of 100 g, and we excluded from all analyses captured birds with estimated fat stores that exceeded this level (55 individuals excluded). Second, we excluded cropped birds from these analyses because equations 1–4 were derived using birds that were uncropped or from which crop contents were removed. Including cropped birds in the analysis would allow the extra mass of the crop contents to inflate the estimates of fat stores.

To determine whether cropped birds carried different amounts of body fat than uncropped birds, we compared fat scores of cropped and uncropped birds for each species, age, and sex class captured during each migration season using chi-square tests. We made 16 comparisons and used a Bonferroni-adjusted significance value of 0.003 for these tests (0.05/16). Third, we included data only if collected by a bander that participated significantly in the study (i.e., had processed more than 100 birds during the study period) and excluded all other data.

To simplify comparing groups of birds that differed widely in body mass (i.e., species and sex classes), we calculated percent total body fat: (fat stores/body mass) \times 100. We square-root-transformed the resulting values to remove the positive skew in the data. We used 3-way ANOVA for each species to examine season, age, and sex differences in fat stores, using transformed percent total body fat as the dependent variable. We conducted analyses using SYSTAT v. 7.01 (SPSS Inc. 1997).

Table 1. Estimated percent total body fat for Sharp-shinned and Cooper's hawks captured during fall (Manzano Mountains, 1992–96) and spring (Sandia Mountains, 1994–96) migration with empty crops in central New Mexico

SPECIES	AGE AND SEX	FALL			SPRING		
		\bar{x}	SE	N	\bar{x}	SE	N
Sharp-shinned Hawk	Adult female	6.75	0.18	389	9.95	0.74	71
	Adult male	5.25	0.12	202	6.05	0.39	24
	Immature female	4.18	0.1	347	6.79	0.6	28
	Immature male	4.74	0.12	264	4.87	0.47	6
Cooper's Hawk	Adult female	9.45	0.2	314	10.62	0.24	224
	Adult male	4.64	0.13	245	4.62	0.12	230
	Immature female	5.52	0.16	238	9.07	0.57	28
	Immature male	3.69	0.11	188	4.15	1.05	3

RESULTS

Fat stores in Sharp-shinned and Cooper's hawks migrating in central New Mexico were generally low, averaging 3–12% of total body mass (Table 1, Fig. 1). Fat scores of cropped and uncropped birds did not differ by species, age, or sex during either season ($\chi^2_{3 \text{ or } 2} < 7.7$, $P > 0.025$). This indicates our use of only uncropped birds to estimate fat stores was justified and resulted in a representative sample.

Fat stores of Sharp-shinned Hawks varied significantly

across season, age, and sex (Table 1, Fig. 1). Overall, percent total body fat was higher in spring than in fall, higher for adults than for immatures, and higher for females than for males; however, significant interactions modified all of these main effects (Table 2). The differences in percent total body fat by season were large for females, and this difference was greater in immature females than in adult females. In contrast, males showed relatively little seasonal variation, with only adult males having more fat in spring than in fall. The difference in percent total body fat by age occurred primarily for females, with males showing little age-related differences.

Fat stores of Cooper's Hawks also varied significantly across season, age, and sex (Table 1, Fig. 1). The pattern of differences was very similar to that of Sharp-shinned Hawks. However, female Cooper's Hawks showed higher percent total body fat than female Sharp-shinned Hawks and male Sharp-shinned Hawks showed marginally higher percent total body fat than male Cooper's Hawks. Otherwise, variation by site, age, and sex mirrored closely the variation of Sharp-shinned Hawks with one notable exception: adult male Cooper's Hawks showed the same percent total body fat in spring and fall (Table 1).

DISCUSSION

Average fat stores in migrating raptors have been estimated at 4–5% of body mass for Common Buzzards in Israel (Gorney and Yom-Tov 1994), 6–9% for American Kestrels (*Falco sparverius*), 6–11% for Sharp-shinned Hawks, and 14–18% for Merlins (*F. columbarius*) in New Jersey (Harden 1993). Our results, in combination with these previous estimates, indicate that many raptors migrate with fat stores in the range of 4–18% of body mass.

Migration season was an important source of variability in fat stores. In females of both species, fat stores were higher in spring than in fall (Table 1, Fig. 1). These differences were not seen in males, except for adult male Sharp-shinned Hawks. One possible adaptive advantage of females having high spring fat stores is that they may

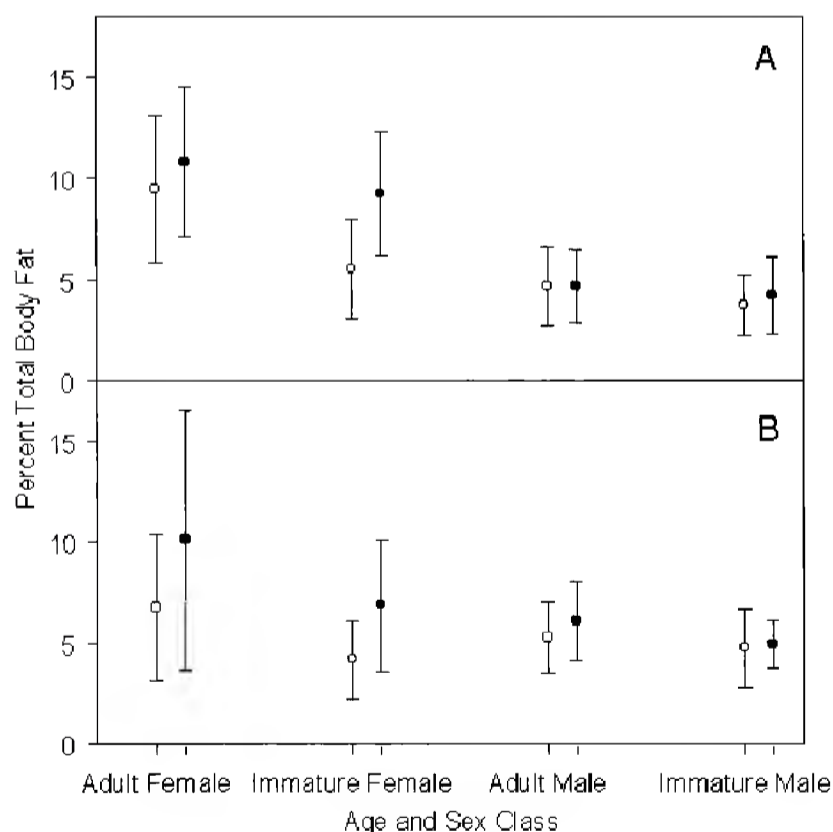


Figure 1. Estimated mean (\pm SD) percent total body fat for (A) Cooper's Hawks and (B) Sharp-shinned Hawks captured with empty crops during spring (solid circles, 1994–96; Sandia Mountains) and fall (open circles, 1992–96; Manzano Mountains) migration in central New Mexico.

Table 2. Three-way analyses of variance examining variation in transformed (square-root) percent total body fat by season, age, and sex for 1331 Sharp-shinned Hawks and 1470 Cooper's Hawks captured during spring (Sandia Mountains, 1994–96) and fall (Manzano Mountains, 1992–96) migration in central New Mexico.

FACTOR	SHARP-SHINNED HAWK		COOPER'S HAWK	
	$F_{1, 1323}$	P	$F_{1, 1462}$	P
Season	23.4	<0.001	10.6	0.001
Age	27.0	<0.001	18.3	<0.001
Sex	16.6	<0.001	125.1	<0.001
Season × age	0.1	0.79	4.0	0.046
Season × sex	9.9	0.002	6.1	0.013
Age × sex	6.2	0.013	4.3	0.039
Season × age × sex	0.4	0.552	1.4	0.241

use those fat stores to aid in developing eggs when spring migration ends and they enter the breeding period. Newton (1979) found that female European Sparrow Hawks (*A nisus*) that did not reach a minimum body mass during courtship failed to lay eggs; this failure to lay eggs could potentially be avoided by accumulating fat stores before or during spring migration. In both Sharp-shinned and Cooper's hawks, adult females showed higher spring fat stores than immatures. This difference may be related to the higher likelihood of adults breeding compared to immatures; however, some female Sharp-shinned and Cooper's hawks breed in their first yr (Rosenfield and Bielefeldt 1993, Bildstein and Meyer 2000, Boal 2001). Nevertheless, Boal (2001) found that females that breed in their first yr (immatures) have later, smaller, and less successful nests than adults. Boal (2001) cited the possibility of physiological constraints as one possible reason for these differences, a constraint that may be reflected in this study as relatively low percent total body fat during spring migration.

Adult females had the highest fat stores among both spring and fall migrants (Table 1, Fig. 1). Sex-specific differences in the fall were less consistent. In the fall, immature female Cooper's Hawks showed higher fat stores than immature male Cooper's Hawks, but the reverse was true for Sharp-shinned Hawks. There may be advantages for females to maintain higher fat stores. Aside from the benefit of carrying extra fat stores prior to the breeding period, females may maintain higher fat stores than males for reasons relating to migration strategies, prey preferences, foraging efficiency, or metabolism.

In all cases except for male Cooper's Hawks in the spring, adults showed higher fat stores than immatures. A similar but more modest difference was observed in spring migrant Common Buzzards in Israel (4% for immatures versus 5% for adults; Gorney and Yom-Tov 1994), and many migrating passerines show a pattern of higher fat stores in adults than immatures (Woodrey and Moore 1997). For raptors, one clear difference between adults and immatures is hunting experience. It is possible

that the net energy gained from prey captures is lower for immatures than adults because of the time spent or the number of attempts made prior to acquiring prey. Such a difference would make capturing prey more expensive, thereby reducing the energy stores gained per prey item. Under such a scenario, the age difference should be reduced during spring migration because of the additional hunting experience acquired by immatures during the winter. A reduction was observed only for female Cooper's Hawks (Table 1), suggesting that the factors that constrain immatures to lower fat stores than adults are maintained through spring migration. Alternatively, the age-specific difference shown in the spring may reflect an age-specific difference in the optimal level of fat stores needed (Lima 1986). How raptors optimize their fat stores (i.e., how they balance the costs and benefits of acquiring and carrying fat stores) has yet to be investigated.

One potential caveat for these results is that there may be a bias in the sampling methodology. Capturing animals by using food as a lure has the potential to result in the capture of an elevated number of food-stressed individuals, relative to the proportion in the migrant population. This bias has been termed "condition bias" by Gorney et al. (1999) and it suggests that the estimated fat stores presented here may underestimate those of the entire migratory population, assuming that there is a relationship between fat stores and a propensity to respond to food lures. Nevertheless, unless condition bias operates differently across season or species, age, and sex groups, our data should portray accurately the pattern of variation in fat stores related to these factors.

In summary, we found low but highly variable levels of fat stores in Sharp-shinned and Cooper's hawks migrating through central New Mexico. These complex patterns merit further investigation, especially because most work investigating fat stores in migrating birds has focused on passerines and shorebirds. Given the variable migration distances (Kerlinger 1989), flight strategies (Kerlinger 1989, Spaar 1997), and foraging behaviors

(Kirkley 1991, Candler and Kennedy 1995, Yosef 1996) of migrating raptors, there may be considerable variation in the need for internal energy storage. The actual relationships between fat stores and the flight strategies, foraging patterns, and metabolic energy needs of migrating hawks have yet to be described.

RESUMEN.—Las reservas de grasa son un substrato de energía importante para las aves migratorias, sin embargo aun existe poca información sobre los depósitos de grasa que llevan las rapaces migratorias. Estimamos los depósitos de grasa de los gavilanes listados (*Accipiter striatus*) y los gavilanes de Cooper (*A. cooperii*) que migraron durante la primavera (1994–96) y el otoño (1992–96) en Nuevo México. Los depósitos de grasa promediaron 3–12% de la masa corporal total. Hubo una variación significativa en los depósitos de grasa por estación, edad, y sexo, y ocurrieron interacciones significativas entre estos efectos. Tres patrones fueron reconocidos: depósitos de grasa más grandes para las hembras en la primavera que para los machos en otoño, y depósitos de grasa más grandes para los adultos que para los inmaduros. Los gavilanes que tenían comida en su bolsa esofagal (buche) no tuvieron grados de grasa diferentes (grasa subcutánea visible) que los gavilanes sin comida en sus buches. Estos resultados sugieren que la variación en los patrones de depósito de grasa en aves rapaces migratorias son complejas y ameritan mayores estudios.

[Traducción de César Márquez]

ACKNOWLEDGMENTS

We would like to thank the many dedicated volunteers and field technicians who made the Manzano and Sandia projects successful. We also thank the following agencies and corporations for financially and logistically supporting the work at our study sites: U.S. Forest Service, Cibola National Forest; New Mexico Department of Game and Fish, Share With Wildlife Program; U.S. Fish and Wildlife Service, Region 2; Central New Mexico Audubon Society; and Intel Corporation. Many local businesses and individuals donated food and supplies to field crews. We thank C. Boal, J. Fry, J. Gessaman, L. Goodrich, J. Kelly, P. Kennedy, C. Lott, T. Meehan, J. Smith, R. Smith, K. Sullivan, M. Vekasy, and an anonymous reviewer for making helpful comments on this manuscript and J. Jewell for her ongoing moral support and patience.

LITERATURE CITED

- BILDSTEIN, K.L. AND K. MEYER. 2000. Sharp-shinned Hawk. In A. Poole and F. Gill [EDS.], *The birds of North America*, No. 482. The Birds of North America, Inc., Philadelphia, PA U.S.A.
- BLEM, C.R. 1980. The energetics of migration. Pages 175–224 in S.A. Gauthreaux, Jr. [ED.], *Animal migration, orientation, and navigation*. Academic Press, New York, NY U.S.A.
- . 1990. Avian energy storage. *Curr. Ornithol.* 7:59–113.
- BOAL, C.W. 2001. Nonrandom mating and productivity of adult and subadult Cooper's Hawks. *Condor* 103:381–385.
- CANDLER, G.L. AND P.L. KENNEDY. 1995. Flight strategies of migrating Osprey: fasting vs. foraging. *J. Raptor Res.* 29:85–92.
- DELONG, J.P. AND J.A. GESSAMAN. 2001. A comparison of noninvasive techniques for estimating total body fat in Sharp-shinned and Cooper's hawks. *J. Field Ornithol.* 72:349–364.
- AND S.W. HOFFMAN. 1999. Differential autumn migration of Sharp-shinned and Cooper's hawks in western North America. *Condor* 101:674–678.
- GESSAMAN, J.A. 1979. Premigratory fat in the American Kestrel. *Wilson Bull.* 91:625–626.
- GORNEY, E. AND Y. YOM-TOV. 1994. Fat, hydration condition, and moult of Steppe Buzzards *Buteo buteo vulpinus* on spring migration. *Ibis* 136:185–192.
- , W.S. CLARK, AND Y. YOM-TOV. 1999. A test of the condition-bias hypothesis yields different results for two species of sparrowhawks (*Accipiter*). *Wilson Bull.* 111:181–187.
- HARDEN, S.M. 1993. Fat content of American Kestrels (*Falco sparverius*) and Sharp-shinned Hawks (*Accipiter striatus*) estimated by total body electrical conductivity. M.S. thesis, Utah State Univ., Logan, UT U.S.A.
- HOFFMAN, S.W., J.P. SMITH, AND J.A. GESSAMAN. 1990. Size of fall-migrant accipiters from the Goshute Mountains of Nevada. *J. Field Ornithol.* 61:201–211.
- , ———, AND T.D. MEEHAN. 2002. Breeding grounds, winter ranges, and migratory routes of raptors in the mountain West. *J. Raptor Res.* 36:97–110.
- JOHNSON, O.W., M.L. MORTON, P.L. BRUNER, AND P.M. JOHNSON. 1989. Fat cyclicity, predicted migratory flight ranges, and features of wintering behavior in Pacific Golden-Plovers. *Condor* 91:156–177.
- KERLINGER, P. 1989. Flight strategies of migrating hawks. University of Chicago Press, Chicago, IL U.S.A.
- KING, J.R. 1970. Adaptive periodic fat storage by birds. *International Ornithological Congress* 25:200–217.
- KIRKLEY, J.S. 1991. Do migrant Swainson's Hawks fast enroute to Argentina? *J. Raptor Res.* 25:82–86.
- LIMA, S.L. 1986. Predation risk and unpredictable feeding conditions: determinants of body mass in birds. *Ecology* 67:377–385.
- MUELLER, H.C., D.D. BERGER, AND G. ALLEZ. 1979. Age and sex differences in size of Sharp-shinned Hawks. *Bird-Banding* 50:34–44.
- , ———, AND ———. 1981. Age, sex, and seasonal differences in size of Cooper's Hawks. *J. Field Ornithol.* 52:112–126.
- NEWTON, I. 1979. Population ecology of raptors. Buteo Books, Vermillion, SD U.S.A.
- ROSENFELD, R.N. AND J. BIELEFELDT. 1993. Cooper's Hawk. In A. Poole and F. Gill [EDS.], *The birds of North America*, No. 75. The Birds of North America, Inc., Philadelphia, PA U.S.A.
- SMITH, N.G., D.L. GOLDSTEIN, AND G.A. BARTHOLOMEW.

1986. Is long-distance migration possible for soaring hawks using only stored fat? *Auk* 103:607–611.
- SPAAR, R. 1997. Flight strategies of migrating raptors: a comparative study of interspecific variation in flight characteristics. *Ibis* 139:523–535.
- SPSS, INC. 1997. SYSTAT® 7.0: Statistics. SPSS, Inc., Chicago, IL U.S.A.
- WOODREY, M.S. AND F.R. MOORE. 1997. Age-related differences in the stopover of fall landbird migrants on the coast of Alabama. *Auk* 114:695–707.
- YOSEF, R. 1996. Raptors feeding on migration at Eilat, Israel: opportunistic behavior or migratory strategy? *J. Raptor Res.* 30:242–245.

Received 21 June 2003; accepted 28 December 2003

J. Raptor Res. 38(2):168–174

© 2004 The Raptor Research Foundation, Inc.

SPANISH RINGING AND RECOVERY RECORDS OF BOOTED EAGLE (*HIERAAETUS PENNATUS*)

IGNACIO S. GARCÍA DIOS¹

Instituto de Investigación en Recursos Cinegéticos (C.S.I.C.-U.C.L.M.), Ronda de Toledo s/n, 13005 Ciudad Real, Spain

KEY WORDS: *Booted Eagle*; *Hieraaetus pennatus*; *mortality*; *longevity*; *philopatry*.

Scientific ringing is a useful method to study many aspects of the life history of birds, and is especially important for the study of migration. Information about migratory routes and wintering areas of raptors is necessary for understanding the factors affecting the conservation of these species outside the breeding areas, such as habitat loss, environmental contamination, or human interference (Zalles and Bildstein 2000). This is particularly relevant for raptor species that perform long migratory journeys, which may be especially vulnerable to human impacts. Furthermore, the concentration of a large number of individuals during migration increases the potential for natural and anthropogenic impacts such as shooting and trapping (Zalles and Bildstein 2000).

The Booted Eagle (*Hieraaetus pennatus*) breeds in southern Europe and winters in Africa (Cramp and Simmons 1980). In winter, Booted Eagles breeding in Europe may move southward into the area where Booted Eagles nest in southern Africa (Brooke et al. 1980, Pepler et al. 2001, D. Pepler and R. Martin unpubl. data). There are some data on the numbers of Booted Eagles crossing the Gibraltar Strait (Bernis 1973, Garzón 1977, Cramp and Simmons 1980, Finlayson 1992, Zalles and Bildstein 2000), the Messina Strait (Thiollay 1989, Zalles and Bildstein 2000), the western Pyrenees (Iribarren 1973, Zalles and Bildstein 2000), the Bab-el-Mandeb Strait (Welch and Welch 1989, Zalles and Bildstein 2000), and other localities during post-nuptial migration to Africa (Zalles

and Bildstein 2000). However, little is known for this species about the routes used during migration to Africa, wintering areas, use of stop-over sites during migration, habitat use in wintering areas, threats outside the breeding season, where first-yr birds spend their second summer, and philopatry. This paper presents a first analysis of ringing and recovery records of this species in Spain for mortality rates, migratory routes, dispersal movements, and longevity in the Booted Eagles.

METHODS

Ringing data presented in this paper were obtained from the Ringing Office of the Spanish General Direction of Nature Conservation. These include only recoveries of Booted Eagles ringed in Spain. From 1973–99, 2080 Booted Eagles were marked with metal rings in Spain (Hernández-Carrasquilla and Gómez-Manzanaque 2000), of which 80 have been recovered (as of 2001). For this analysis, the recovery records have been divided into four periods: (1) breeding, 15 March–14 September; (2) post-nuptial migration, 15 September–14 November (15 d before of the peak passage through the Gibraltar Strait until the beginning of the wintering period; Bernis 1973); (3) winter, 15 November–14 February (Bernis 1980); and (4) pre-nuptial migration, 15 February–14 March (only one case that has not been included in the analyses). Eagles were classified into one of three age classes: juveniles (<1 yr), immature (2–3 yr), and adults (>3 yr; Newton 1979, Cramp and Simmons 1980).

RESULTS AND DISCUSSION

Causes of Recovery. From 80 Booted Eagles ringed in Spain and subsequently recovered, 58.8% were found dead, 18.8% were found alive and immediately released, and 13.8% were found alive but were not released due to their poor physical condition. No detailed information could be obtained for the remaining 8.8% of ringed ea-

¹ Present address: Plazuela del Padre Felipe Fernández nº 1–2º, 05416, EL ARENAL Ávila, Spain; e-mail address: pennatus@latinmail.com

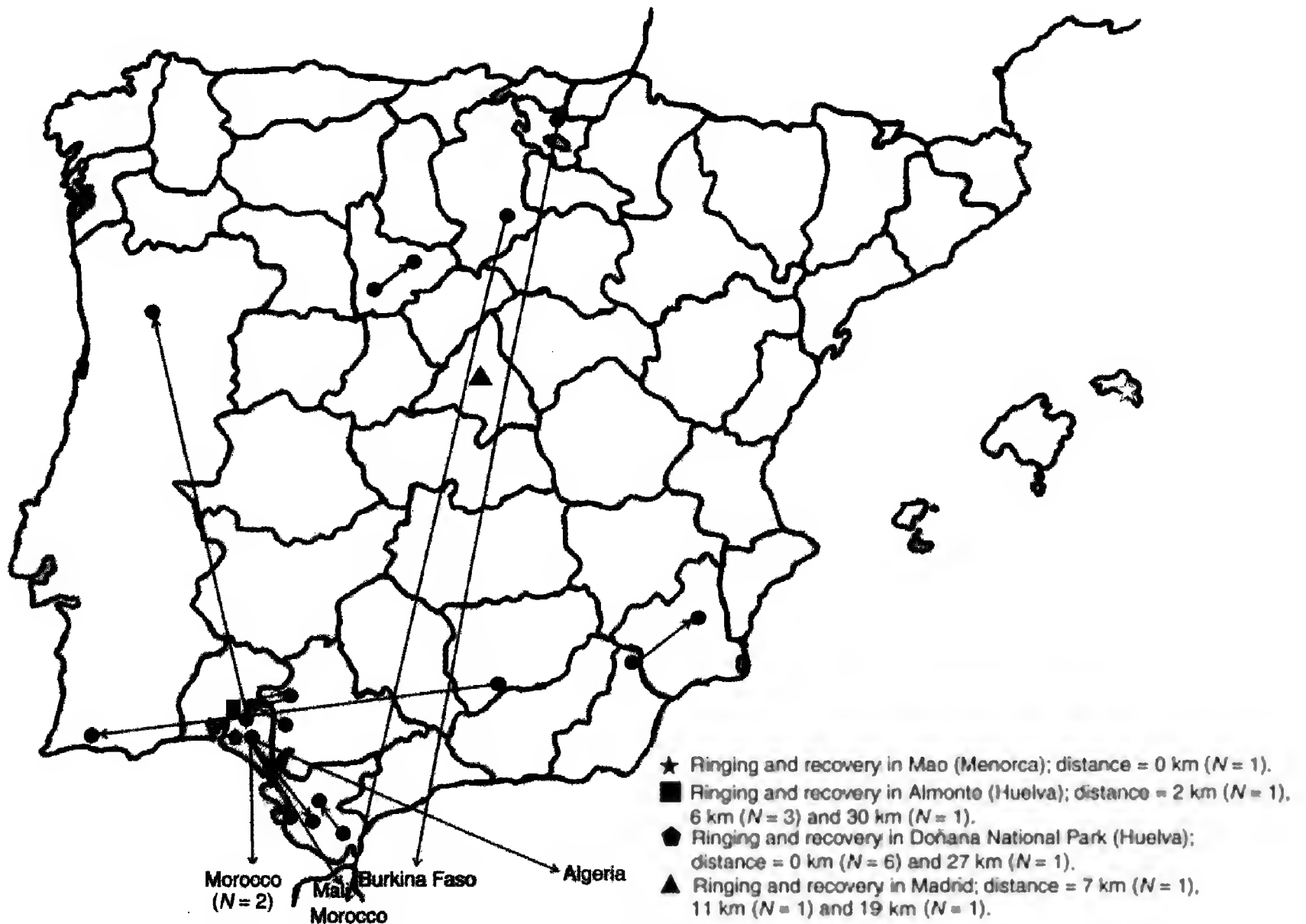


Figure 1. Ringing and recovery localities during breeding period (15 March–14 September) of Booted Eagles marked in Spain. Recoveries of birds that were ringed during the same breeding season were excluded.

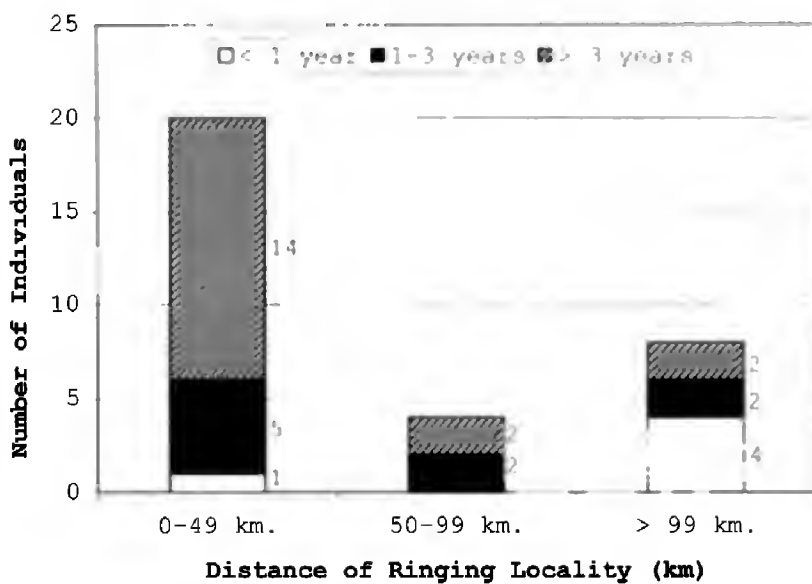


Figure 2. Distribution of dispersal distances of Booted Eagles from their natal place during breeding season, excluding data of birds ringed and recovered during the same breeding season.

gles. The percentage of birds found dead was greater for juveniles and immatures (combined; 72%, $N = 50$) than for adults (36.7%, $N = 30$). This difference was statistically significant (Yate's corrected $\chi^2 = 8.26$, $P = 0.01$). This is consistent with the pattern that young raptors tend to have higher mortality rates than adults (Newton 1979).

Causes of mortality were: shooting (21.3%), drowning (14.9%), collision with electric powerlines or electrocution (8.5%), trapping (6.4%), general trauma (6.4%), poison (4.3%), predation by other raptors (2.1%), predation by other wild animals (2.1%), collision with cars (2.1%), and unknown (31.9%).

Causes of mortality in juveniles were largely related to human activities (drowning 29.2% and shooting 20.8%). The inexperience of juveniles may explain the high number of individuals found drowned (Newton 1979), as this cause of mortality was never recorded for adult birds. The primary cause of mortality for adults was shooting (27.3%), which was also common for juveniles (20.8%) and among immatures (20.0%). Thus, illegal killing seems to be a significant mortality factor for this species,



Figure 3. Ringing and recovery localities (filled circles) during autumn migration (15 September–14 November) of Booted Eagles marked in Spain. Recoveries within Balearic Islands, where the species is sedentary, have been excluded.

including within Spain, where illegal predator control is still an important conservation problem (Villafuerte et al. 1998).

With respect to those birds found alive and immediately released, the circumstances of the recovery were trapping (40.9%), found inside buildings (13.6%), found with general trauma (9.1%), or found chilled (4.5%). Among the birds found alive, but not immediately released, 36.4% had general trauma, 27.3% were exhausted, 9.1% had been shot, 9.1% had collided with electric powerlines, and the causes were unknown for the remaining 18.1%. There were seven records with no information about the recovery.

Dispersal Distances. The longest distances between ringing and recovery locations for Booted Eagles marked in Spain were recorded for birds wintering or migrating in sub-Saharan African countries. The greatest distance record was for an eagle ringed in Alava (northern Spain) and recovered after 1093 d in Burkina Faso (3530 km). Three other records corresponding to long migration journeys were of nestlings ringed in Murcia (southeastern Spain) and Doñana National Park (province of Huel-

va). The first was trapped after 184 d in Nigeria (3110 km). The second was found predated by a raptor 503 d later in Togo (2980 km). The third was found dead 546 d later in Mali (2708 km).

Philopatry. To study dispersal distances after the first wintering season, I selected the recovery records made during the breeding season, excluding the records of birds ringed and recovered during the same breeding season. Of the 32 selected records, 24 (75.0%) were made at a distance less than 100 km from the birthplace (Fig. 1). Seven of these records were made at the same locality where the birds were ringed (six adults and one bird younger than one yr). Raptors tend to be philopatric, whereby young birds tend to return to natal areas when they reach breeding age (e.g., Newton 1979, Newton et al. 1994, Forero et al. 2002), and my results support this for Booted Eagles. With respect to young and immature individuals, 57.1% were recovered between 0–100 km of their birthplace. This suggests that even young, nonbreeding birds may return to their natal areas during the next breeding season. However, there are seven cases of Booted Eagles younger than 1 ($N = 5$) and

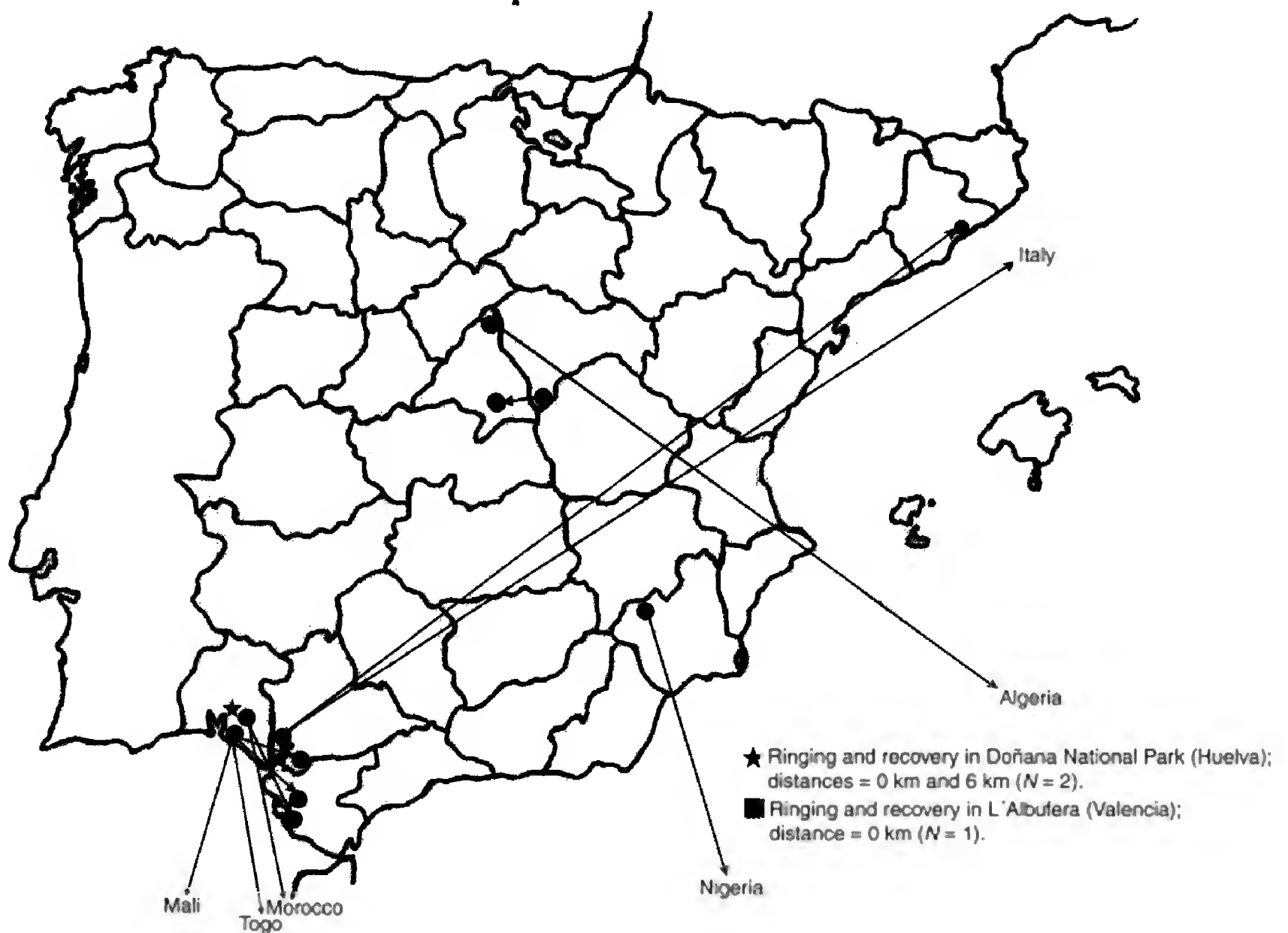


Figure 4. Ringing and recovery localities during winter (15 November–14 February) of Booted Eagles marked in Spain. Recoveries within Balearic Islands, where the species is sedentary, have been excluded.

2-yr old ($N = 2$) recovered very far from their birthplace during the following breeding season (locations of recoveries were Algeria, Burkina Faso, Mali, and Morocco). The recovery distances were significantly different among age classes (ANOVA with log-transformed dispersal distances; $F_{2,29} = 3.9$, $P = 0.035$; Fig. 2), and this suggests that probably young eagles tend to disperse further from their natal area than immatures or adult birds during breeding season. In other raptors, the proportion of individuals found near their natal areas increase with age, and young disperse greater distances in the breeding season (Newton 1979).

Longevity. The longevity record in the wild was a bird ringed as a nestling in the province of Madrid (central Spain) and recovered dead in a nearby area almost 14-yr later (5084 d-old). A 4638 d-old Booted Eagle ringed in the province of Huelva was also recovered in the Khenifra (Morocco).

Migration Direction. By using only Booted Eagles ringed and recovered in the same season (the records of the sedentary population in Balearic Islands have been

excluded), I obtained a picture of the migration routes for the Spanish population (Fig. 3). The records available showed one movement east-northeast of ringing areas (Cáceres), two south-southeast of ringing areas (Cádiz), and one recovered south-southwest of the ringing area (Murcia). Recovery made at east-northeast could be due to a pre-migratory movement of bird looking for a more productive site during summer months, or perhaps represented a bird exploring possible future breeding areas (Newton 1979, Olea 2001).

Wintering Areas. Booted Eagles recovered between 15 November and 14 February should reflect wintering areas used by the Spanish population (Fig. 4). I selected 14 records, which can be divided into five groups: two eagles recovered east-northeast of ringing areas (Barcelona, Spain; Firenze, Italy), five individuals recovered in Africa during winter (Morocco, Togo, Mali, Algeria, and Nigeria; Fig. 5), one sedentary individual (Valencia, Spain), five birds wintering in southern Spain (Cádiz, Huelva, Sevilla), and one bird wintering in central Spain (Madrid).



Figure 5. Recovery locations of Booted Eagles during breeding and winter periods in Africa.

Winter recoveries at east-northeast breeding areas were surprising, because Booted Eagles generally are known to fly south from Europe to Africa (Brown and Amadon 1968, Cramp and Simmons 1980) similar to other European migratory raptors (González and Merino 1990, González 1991, Donazar 1993, Triay unpubl. data). These two winter localities for Booted Eagles, Barcelona and Firenze, are on the Mediterranean coast, where the mild winters could support a high density of passerines and a relatively high winter activity of reptiles. Passerines and reptiles are among the main prey of breeding Booted Eagles in Spain (I. García Dios unpubl. data). Sunyer and Viñuela (1996) and Martínez and Sánchez-Zapata (1999) previously suggested that several raptor species are more frequently wintering in Mediterranean areas over the last 20 yr, instead of migrating to Africa. These two Booted Eagle records are consistent with this suggestion. Despite the lower winter recovery of Spanish Booted Eagles in Africa than in Europe, the primary winter quarters for the species is Africa (Brown and Amadon 1968, Cramp and Simmons 1980). This is clearly supported by the large numbers of birds crossing the Strait of Gibraltar (Bernis 1973). The higher recovery frequency in Europe in this analysis was likely due to higher reporting rates in Europe, and not because more eagles were wintering in Europe.

RESUMEN.—En este artículo presentamos una aproximación sobre la mortalidad, migración, dispersión, y longevidad del aguililla calzada (*Hieraaetus pennatus*) basándonos en las recuperaciones de individuos de esta especie marcados con anillas metálicas. Los resultados sugieren que los jóvenes tienen una tasa de mortalidad relativamente alta, en especial debido a su inexperiencia, y que el tiroteo ilegal sigue siendo una causa de mortalidad importante. Los jóvenes tienden a dispersarse mayores distancias que los individuos adultos, aunque en general se observa una clara tendencia filopátrica. Se registran movimientos premigratorios e invernada en latitudes más norteañas que las de reproducción, lo que puede estar relacionado con una tendencia creciente a la sedentarización en el Mediterráneo. La máxima longevidad registrada por este método es de 14 años.

[Traducción del autor]

ACKNOWLEDGMENTS

I thank my wife for her support of my work and for cheering me up during the difficult times of my Doctoral dissertation. I also appreciate the support of Manuel García Tornero, Javier Muñoz Familiar, and Marcos González Jiménez. The Ringing Office of the Spanish General Direction of Nature Conservation provided ringing and recovery data. I would also like to thank Juan Góndio for reviewing the English version of this manuscript. David Pepler, Javier Viñuela, and two anonymous referees made useful comments on previous drafts.

LITERATURE CITED

- BERNIS, F. 1973. Migración de Falconiformes y *Ciconia* spp. por Gibraltar, Verano-Otoño 1972–73. Primera Parte. *Ardeola* 19:151–224.
- . 1980. La migración de las aves en el Estrecho de Gibraltar. Vol. I, *Aves planeadoras*. Universidad Complutense, Madrid, Spain.
- BROOKE, R.K., R. MARTIN, J. MARTIN, AND E. MARTIN. 1980. The Booted Eagle, *Hieraaetus pennatus*, as a breeding species in South Africa. *Gerfaut* 70:297–304.
- BROWN, L. AND D. AMADON. 1968. Eagles, hawks, and falcons of the world. Country Life Books, London, U.K.
- CRAMP, S. AND K.E.L. SIMMONS. 1980. The birds of the western palearctic. Vol. II. Oxford Univ. Press, Oxford, U.K.
- DONÁZAR, J.A. 1993. Los Buitres Ibéricos: biología y conservación. J.M. Reyer, Madrid, Spain.
- FINLAYSON, C. 1992. Birds of the Strait of Gibraltar. T. & A.D. Poyser, London, U.K.
- FORERO, M., J.A. DONÁZAR, AND F. HIRALDO. 2002. Causes and fitness consequences of natal dispersal in a population of Black Kites. *Ecology* 83:858–872.
- GARZÓN, J. 1977. Birds of prey in Spain, the present situation. Pages 159–170 in R.D. Chancellor [Ed.], Proceedings of the World Conference on Birds of Prey, Vienna, 1975. International Council for Bird Preservation, Cambridge, U.K.
- GONZÁLEZ, J.L. AND M. MERINO. 1990. El Cernicaco primitivo (*Falco naumanni*) en la Península Ibérica. ICONA, Madrid, Spain.
- GONZÁLEZ LÓPEZ, J.L. 1991. El Aguilucho Lagunero *Circus aeruginosus* (L., 1748) en España: situación, biología de la reproducción, alimentación y conservación. Ministerio de Agricultura, Pesca y Alimentación. ICONA, Madrid, Spain.
- HERNÁNDEZ-CARRASQUILLA, F. AND A. GÓMEZ-MANZANAQUE. 2000. Informe sobre la campaña de anillamiento de aves en España. *Ecología* 14:291–330.
- IRIBARREN, J.J. 1973. Observación y recuento de rapaces. *Vida Silvestre* 12:260–265.
- MARTÍNEZ, J.E. AND J.A. SÁNCHEZ-ZAPATA. 1999. Invernada del Aguililla Calzada (*Hieraaetus pennatus*) y Culebrera Europea (*Circaetus gallicus*) en España. *Ardeola* 46:93–96.
- NEWTON, I. 1979. Population ecology of raptors. T. & A D Poyser, London, U.K.
- , P.E. DAVIS, AND D. MOSS. 1994. Philopatry and population growth of Red Kites, *Milvus milvus*, Wales. *Proc. R. Soc. Lond.* 257:317–323.
- OLEA, P. 2001. Postfledging dispersal in the endangered Lesser Kestrel *Falco naumanni*. *Bird Study* 48:110–115.
- PEPLER, D., R. MARTIN, AND H.J. VAN HENSBERGEN. 2001. Estimating the breeding population of Booted Eagles in the Cape Province, South Africa. *J. Raptor Res.* 35: 15–19.
- SUNYER, C. AND J. VIÑUELA. 1996. Invernada de rapaces

- (*O. falconiformes*) en España Peninsular e Islas Baleares. Pages 361–370 in J. Muntaner and J. Mayol [EDS.], *Biología y Conservación de las rapaces Mediterráneas*, 1994. Monografías No. 4. SEO, Madrid, Spain.
- THIOLLAY, J.-M. 1989. Distribution and ecology of palearctic birds of prey wintering in west and central Africa. Pages 95–109 in B.-U. Meyburg and R.D. Chancellor [EDS.], *Raptors in the modern world: proceedings of the world conference on birds of prey and owls*. World Working Group on Birds of Prey and Owls, Berlin, Germany.
- VILLAFUERTE, R., J. VIÑUELA, AND J.C. BLANCO. 1998. Extensive predation persecution caused by population crash in a game species: the case of Red Kites and rabbits in Spain. *Biol. Conserv.* 84:181–188.
- WELCH, G. AND H. WELCH. 1989. Autumn migration across the Bab-el-Mandeb Straits. Pages 123–125 in B.-U. Meyburg and R.D. Chancellor [EDS.], *Raptors in the modern world: proceedings of the world conference on birds of prey and owls*. World Working Group on Birds of Prey and Owls, Berlin, Germany.
- ZALLES, J.I. AND K.L. BILDSTEIN (EDS.). 2000. *Raptor watch: a global directory of raptor migration sites*. BirdLife International, Cambridge, U.K. and Hawk Mountain Sanctuary, Kempton, PA U.S.A.

Received 27 November 2001; accepted 20 June 2003

J Raptor Res. 38(2):174–177

© 2004 The Raptor Research Foundation, Inc.

DIET SHIFT OF BARN OWLS (*TYTO ALBA*) AFTER NATURAL FIRES IN PATAGONIA, ARGENTINA

MERCEDES SAHORES AND ANA TREJO¹

Centro Regional Bariloche, Universidad Nacional del Comahue, 8400 Bariloche, Rio Negro, Argentina

KEY WORDS: *Barn Owl*; *Tyto alba*; *fire perturbations*; *dietary shift*; *Patagonia*.

The Barn Owl (*Tyto alba*) is broadly distributed in Argentina and is found in several types of habitats such as woodlands, grasslands, and semideserts (Canevari et al. 1991). Barn Owls feed primarily on small mammals, although prey species differ slightly among different localities even in the same geographic region (e.g., in Patagonia see Travaini et al. 1997, Pillado and Trejo 2000), which implies that owls show considerable plasticity and are opportunist predators, capturing the most abundant or vulnerable prey.

In this study we describe the diet composition of Barn Owls in a locality where the type of vegetation (and the associated small fauna) changed drastically after successive natural fires in the area. Our objective is to record any change in prey use before and after the fires to assess the impact of this disturbance on the owls' feeding behavior.

METHODS

The study site was located in northwestern Patagonia (41°03'S, 70°59'–71°00'W, 900 m above sea level). The area is a transition between the arid Patagonian steppe to the east and the humid *Nothofagus* forests to the west. The area is mountainous with rocky outcrops (with caves used by owls for roosting), and the vegetation is domi-

nated by bunchgrasses (*Stipa speciosa*), cushion bushes (*Mulinum spinossum*), and scattered bushes (*Fabiana imbricata*, *Discaria articulata*, *Maytenus chubutensis*, and *Berberis buxifolia*). At times, low trees (*D. chacaye*) form small-gallery forests. Mean annual temperature is 8°C, and mean annual rainfall is 800 mm (Paruelo et al. 1998).

Diet of Barn Owls was studied from autumn–spring 1998 by analyzing pellets collected seasonally under two roosts (likely including 1–2 owl home ranges). We divided the yr into seasons: summer (December–February), autumn (March–May), winter (June–August), and spring (September–November). In the Austral summer 1998–1999, the area was affected by successive natural fires that destroyed most of the vegetation and left large patches of bare soil. The owls abandoned the known roosting sites, but did not leave the area. We continued collecting pellets in the summer and autumn 2000, after finding new roosts in an unburned area adjacent to the burned patches and not far from the abandoned roosting sites (ca. 300 m).

Pellets were air dried and dissected using standard techniques (Marti 1987). Prey remains in pellets were identified using keys (Pearson 1995) and by comparison with reference collections. Mammalian prey were classified to species and quantified by counting skulls and mandible pairs. Birds were identified to family level and quantified by counting skulls, while insects were classified to order and quantified by counting head capsules and mandibles.

Biomass of each prey category in the total biomass of the diet was calculated by multiplying mean body mass of individuals by the number of individuals in pellets and expressed as a percent of total prey biomass consumed.

¹ E-mail address: strix@bariloche.com.ar

Geometric mean weight of prey (*GMWP*) in the diet was calculated following Marti (1987). Mean prey weights were taken from literature (Pearson 1983, Kramer et al. 1999), and from our own records. Mean weight of birds and coleopterans was taken from Donazar et al. (1997). Food-niche overlap (*O*) between diets in the pre- and post-fire periods was assessed by Pianka's (1973) index: $O = \sum p_i q_i / (\sum p_i^2 \sum q_i^2)^{1/2}$, where p_i is the frequency of a prey type in 1998, and q_i is the frequency of the same prey type in 2000. It ranges from 0 (no overlap)–1 (complete overlap). To test for differences in frequencies of prey categories in the diet among seasons, and before and after fires, we used contingency tables analyzed using *G*-tests of independence (Zar 1996). We grouped less common prey species so <20% of the expected frequencies was <5. We attained that by lumping all species with an observed frequency >4. The criterion for statistical significance was $P < 0.05$.

RESULTS

Our results revealed that Barn Owls fed largely on rodents (99.7% and 95.7% of the total prey items in 1998 and 2000, respectively), although they also consumed a small number of lagomorphs, birds (Emberizidae) and coleopterans (Table 1). The mean number of prey/pellet was 1.7 (SD = 0.8; range = 1–4; $N = 221$) in 1998 and 2.4 (SD = 1.3; range = 1–5; $N = 58$) in 2000 associated with a higher consumption of smaller-size prey (Table 1).

There were significant differences in diet composition among seasons in 1998 ($G = 36.3$, $df = 8$, $P < 0.05$), maybe related to fluctuations in prey population abundance throughout the yr. However, we note that in 1998, *Reithrodon auritus*, *Loxodontomys micropus*, *Abrothrix longipilis*, and *Oligoryzomys longicaudatus* made up 70–90% of total number of prey in all seasons. We found no significant differences between the two seasons sampled in 2000 ($G = 6.0$, $df = 2$, $P > 0.05$). Consequently, we pooled data for further analysis. We found significant differences ($G = 197.9$, $df = 5$, $P < 0.05$) in diets between 1998 and 2000. *Reithrodon auritus* decreased, *L. micropus* and *O. longicaudatus* almost disappeared, and *Eligmodontia morgani* showed a marked increase (from 3% in 1998 to >50% in 2000). *Reithrodon auritus* contributed most to the prey biomass in both yr, followed by *L. micropus* in 1998, and by *E. morgani* and *Ctenomys haigi* in 2000.

Food-niche overlap between yr was 0.329. Geometric mean weight of prey was 44.0 g in 1998, and 24.7 g in 2000, indicating that much lighter prey were consumed in the later yr (Table 1).

DISCUSSION

Prey composition in the owls' diet that we observed may have reflected changes in the small mammal fauna as a response to vegetational changes associated with fire. In 1998, the diet of Barn Owls was quite similar to that found in another site of similar characteristics (40°47'S, 71°07'W; Pillado and Trejo 2000). Both sites present a mixed small mammal fauna of forest and steppe-adapted species (Pearson and Pearson 1982). In this type of hab-

itat, green-grass eaters (*R. auritus*) predominated in open areas, while scansorial species (*O. longicaudatus* and *L. micropus*) were associated with bushes, and also some wide-ranging species as *A. longipilis* were found (Pearson 1995, Guthmann et al. 1997, Lozada et al. 2000). In our study site, removal of vegetation by fire created a large patch of open habitat. This produced a decrease in species richness associated with reductions in vegetational complexity, and increases in the abundance of species suited to exploit open habitats (Ojeda 1989). Ojeda (1989) compared unburned and burned sites in the Monte desert of Argentina, and found that *E. typus* (closely related to *E. morgani*; Kelt et al. 1991) was more abundant in the burned sites (characterized by a low-vegetational cover) than in the unburned sites. He concluded that *E. typus* increased numbers in burned areas due to its general morphological and physiological adaptations to xeric existence in open habitats. *Eligmodontia morgani* is a small mouse commonly caught by aerial predators in open habitats (Pearson et al. 1987), a habitat association which may increase its risk of predation (Kotler 1984). Due to its small size, this species would be consumed by owls in absence of other energetically more profitable prey (Jaksic and Marti 1984). N. Guthmann (pers. comm.) live-trapped small mammals in burned and unburned areas shortly after the completion of our study (March 2001). Trapping in the burned site yielded more than 60% *E. morgani* by frequency of occurrence, followed by *R. auritus* (another open-habitat mouse; Pearson 1988).

The decrease of *L. micropus* and *O. longicaudatus* in the diet, rodents associated with bushy habitats (Pearson 1983), was probably also associated with the fires, which removed almost all vegetation.

Abrothrix longipilis maintained a similar proportion in the diet before and after the fires. This is a species associated with some vegetation cover (Pearson 1983), although can be found almost in all habitats from forests to arid zones. This flexibility in its habitat use probably enabled this species to survive after a severe transformation of the vegetation.

Although the number of pellets found in 2000 was not very large, the marked changes observed in the diet of Barn Owls after fire presumably show opportunistic behavior by this species. Instead of switching hunting area, to pursue a specific prey, Barn Owls shifted the diet as the prey community adjusted to vegetation changes. As other authors have observed (e.g., Bosè and Guidali 2001), the Barn Owl diet seems to reflect changes in the composition of the small mammal community, which are their main prey.

RESUMEN.—Se estudió la dieta de la lechuza de campanario (*Tyto alba*) durante dos períodos de tiempo en un área montañosa semi-árida del noroeste de la Patagonia argentina. Los períodos analizados fueron antes (1998) y después (2000) de que el área fuera afectada por in-

Table 1. Percent frequency (Freq) and percent biomass (Bio) of food items found in pellets of Barn Owls in northwestern Argentine Patagonia before (1998) and after (2000) the area was burned by fires (1999).

PREY TYPES	MASS (g)	1998						2000			
		AUTUMN		WINTER		SPRING		POOLED			
		FREQ	BIO	FREQ	BIO	FREQ	BIO	FREQ	BIO		
Mammals											
Rodents											
<i>Ctenomys haigi</i>	146.2	1.5	4.5	—	—	—	—	1.1	3.2	4.3	19.3
<i>Abrothrix longipilis</i>	27.6	14.6	8.0	9.5	5.6	12.5	7.8	13.3	7.5	9.4	7.9
<i>Abrothrix xanthorhina</i>	15.3	4.6	1.4	3.6	1.2	15.6	5.4	5.3	1.7	4.3	2.0
<i>Akodon iniscatus</i>	15.3	—	—	—	—	—	—	—	—	0.7	0.3
<i>Chelemys macronyx</i>	66.8	0.4	0.5	—	—	—	—	0.3	0.4	—	—
<i>Eligmodontia morgani</i>	17.5	4.2	1.5	—	—	3.1	1.2	3.2	1.1	52.2	27.7
<i>Euneomys chinilloides</i>	84.7	0.8	1.3	—	—	—	—	0.5	—	—	—
<i>Irenomys tarsalis</i>	41.3	—	0.3	—	—	—	—	—	—	—	—
<i>Loxodontomys micropus</i>	56.2	26.2	29.2	31.0	37.1	18.8	23.9	26.6	30.5	0.7	1.2
<i>Notiomys edwardsii</i>	21.3	0.4	0.2	—	—	—	—	0.3	—	—	—
<i>Oligoryzomys longicaudatus</i>	24.1	3.8	1.8	21.4	11.0	21.9	12.0	9.3	4.6	2.2	1.6
<i>Phyllotis xanthopygus</i>	57.5	—	—	2.4	2.9	3.1	4.1	0.8	0.9	1.4	2.5
<i>Reithrodon auritus</i>	63.8	34.6	43.9	28.6	38.9	15.6	22.7	31.6	41.2	14.5	28.1
Unidentified rodents	43.3	8.5	7.3	3.6	3.3	6.3	6.1	7.2	6.3	5.8	6.1
Lagomorphs											
<i>Lepus europaeus</i>	235.0	—	—	—	—	3.1	16.7	0.3	1.3	—	—
Birds	70.0	—	—	—	—	—	—	—	—	1.4	3.1
Coleopterans	2.0	—	—	—	—	—	—	—	—	2.9	0.2
Total prey			260		84		32		376		138
Total pellets			145		57		19		213		58

cendios naturales sucesivos que destruyeron la vegetación casi completamente. En ambos períodos los roedores representaron más del 95% de las presas consumidas. Sin embargo, se observó un gran cambio en la composición de las mismas. En 1998, *Reithrodon auritus*, y otros roedores sigmodontinos asociados a ambientes arbustivos fueron los más consumidos. En 2000, *Eligmodontia morgani*, especie típica de microhábitats abiertos con suelo desnudo, representó más del 50% de la dieta, y las especies asociadas a arbustos casi desaparecieron. Nuestros resultados indicaron que *T. alba* fue un predador oportunista al alimentarse de pequeños mamíferos, y muy sensible a las modificaciones en la abundancia de las presas.

[Traducción de los autores]

ACKNOWLEDGMENTS

We thank Otto Bitterman for letting us work in Estancia San Ramón. We also thank Diego Añón Suarez for insect identification, and Ulyses Pardiñas for his comments. We are also grateful to M.I. Bellocq, C. Marti, and J. Vargas for their valuable comments that greatly improved this manuscript.

LITERATURE CITED

- BOSÈ, M. AND F. GUIDALI. 2001. Seasonal and geographic differences in the diet of the Barn Owl in an agroecosystem in northern Italy. *J. Raptor Res.* 35:240–246.
- CANEVARI, M.P., P. CANEVARI, G.R. CARRIZO, G. HARRIS, J. RODRIGUEZ MATA, AND R.J. STRANECK. 1991. Nueva guía de las aves argentinas. Fundación Acindar, Buenos Aires, Argentina.
- DONÁZAR, J.A., A. TRAVAINI, O. CEBALLOS, O.M. DELIBES, AND F. HIRALDO. 1997. Food habits of the Great Horned Owl in northwestern Argentine Patagonia: the role of introduced lagomorphs. *J. Raptor Res.* 31:364–369.
- GUTHMANN, N., M. LOZADA, J.A. MONJEAU, AND K.M. HEINEMANN. 1997. Population dynamics of five sigmodontine rodents of northwestern Patagonia. *Acta Theriol.* 42:143–152.
- JAKSIC, F. AND C.D. MARTI. 1984. Comparative food habits of *Bubo* owls in Mediterranean-type ecosystems. *Condor* 86:288–296.
- KELT, D.A., R.E. PALMA, M.H. GALLARDO, AND J.A. COOK. 1991. Chromosomal multiformity in *Eligmodontia* (Muridae, Sigmodontine), and verification of the status of *E. morgani*. *Z. Saeugetierkunde* 56:352–358.
- KOTLER, B.P. 1984. Risk of predation and the structure of desert rodent communities. *Ecology* 65:689–701.
- KRAMER, K.M., J.A. MONJEAU, E.C. BIRNEY, AND R.S. SIKES. 1999. *Phyllotis xanthopygus*. *Mammal. Sp.* 617:1–7.
- LOZADA, M., N. GUTHMANN, AND N. BACCALA. 2000. Microhabitat selection of five sigmodontine rodents in a forest-steppe transition zone in northwestern Patagonia. *Reithrodon. Stud. Neotrop. Fauna Environ.* 35:85–90.
- MARTI, C.D. 1987. Raptor food habits studies. Pages 67–80 in B.A.G. Pendleton, B.A. Millsap, K.W. Cline, and D.M. Bird [EDS.], Raptor management techniques manual. Sci. Tech. Ser. 10. Nat. Wildl. Fed., Washington DC, U.S.A.
- OJEDA, R.A. 1989. Small-mammal responses to fire in the Monte Desert, Argentina. *J. Mammal.* 70:416–420.
- PARUELO, J.M., A. BELTRÁN, E. JOBBÁGY, O.E. SALA, AND R.A. GOLLUSCIO. 1998. The climate of Patagonia: general patterns and controls on biotic processes. *Ecol Austral.* 8:85–101.
- PEARSON, O.P. 1983. Characteristics of a mammalian fauna from forests in Patagonia, southern Argentina. *J. Mammal.* 64:476–492.
- . 1988. Biology and feeding dynamics of a South American herbivorous rodent. *Reithrodon. Stud. Fauna Neotrop. Environ.* 23:25–39.
- . 1995. Annotated keys for identifying small mammals living in or near Nahuel Huapi National Park or Lanín National Park, southern Argentina. *Mastozool. Neotrop.* 2:99–148.
- AND A.K. PEARSON. 1982. Ecology and biogeography of the southern rainforests of Argentina. Pages 129–144 in A.M. Mares and H.H. Genoways [EDS.], Mammalian biology in South America. Spec. Publ. Ser. 6. Pymatuning Lab. Ecol. Univ. of Pittsburgh, Linesville, PA U.S.A.
- , S. MARTIN, AND J. BELLATI. 1987. Demography and reproduction of the silky desert mouse (*Eligmodontia*) in Argentina. *Fieldiana Zool.* 39:413–431.
- PIANKA, E.R. 1973. The structure of lizard communities. *Ann. Rev. Ecol. Syst.* 4:53–74.
- PILLADO, M.S. AND A. TREJO. 2000. Diet of the Barn Owl (*Tyto alba tuidara*) in northwestern Argentine Patagonia. *J. Raptor Res.* 34:334–338.
- TRAVAINI, A., J.A. DONÁZAR, O. CEBALLOS, A. RODRÍGUEZ, F. HIRALDO, AND M. DELIBES. 1997. Food habits of common Barn Owls along an elevational gradient in Andean Argentine Patagonia. *J. Raptor Res.* 31:59–64.
- ZAR, J.H. 1996. Biostatistical analysis. Prentice Hall, Upper Saddle River, NJ U.S.A.

Received 13 September 2002; accepted 28 February 2004

J Raptor Res. 38(2):178–181

© 2004 The Raptor Research Foundation, Inc.

TROPHIC RELATIONSHIPS BETWEEN WHITE-TAILED KITES (*ELANUS LEUCURUS*) AND BARN OWLS (*TYTO ALBA*) IN SOUTHERN BUENOS AIRES PROVINCE, ARGENTINA

LUCAS M. LEVEAU¹ AND CARLOS M. LEVEAU
Alte. Brown 2420, 1° A, 7600 Mar del Plata, Argentina

ULYSES F.J. PARDIÑAS
Centro Nacional Patagónico, Casilla de Correo 128, 9120 Puerto Madryn, Argentina

KEY WORDS: *Barn Owl*; *Tyto alba*; *White-tailed Kite*; *Elanus leucurus*; *diet*; *competition*; *trophic overlap*.

Similar species often partition resources along three dimensions: the habitat used for foraging, the kind of food eaten, and the time of day that foraging occurs (Cody 1968, Schoener 1974a, 1974b, Jaksic 1988). Time is considered to be the least important in niche partitioning (Schoener 1974a, 1974b). Moreover, Jaksic (1982) argued that time of activity was not adequate to separate niches of hawks and owls. On the other hand, Marti and Kochert (1995) studied the similarity in the diets of two generalistic raptors, Red-tailed Hawks (*Buteo jamaicensis*) and Great Horned Owls (*Bubo virginianus*), concluding that time of activity resulted in diet differences sufficient to separate the niches of these two raptors.

The diet of the Barn Owl (*Tyto alba*) has been studied intensively in some regions of Argentina (Bellocq 2000, Pardiñas and Cirignoli 2002). The White-tailed Kite (*Elanus leucurus*), on the other hand, is poorly known, and its biology in South America has been addressed by only a few contributions (e.g., Meserve 1977, Schlatter et al. 1980, Leveau et al. 2002).

White-tailed Kites are mainly diurnal, although also have been reported to be crepuscular (Jaksic et al. 1987, Mendelsohn and Jaksic 1989); Barn Owls are mostly nocturnal, but occasionally hunt during the day (del Hoyo et al. 1999). These two raptors, common in the Buenos Aires province (Narosky and Di Giacomo 1993), are well-known rodent predators (>90% of prey in most studies; Mendelsohn and Jaksic 1989, Bellocq 2000). Both species occupy similar habitat in sympatry (Narosky and Yzurieta 1987, Narosky and Di Giacomo 1993). Additionally, their body masses are very similar (White-tailed Kite $\bar{x} = 302.2$ g and Barn Owl $\bar{x} = 307$ g; Schlatter et al. 1980, Jaksic et al. 1992, respectively). Therefore, the period of hunting activity may be a key factor separating the niches of these two species. Here, we compare the small mammals consumed by White-tailed Kites and Barn Owls in a southern Buenos Aires area, Argentina, and examine the degree of dietary similarity to evaluate if activity periods separate niches of these species.

METHODS

We collected data in Villa Cacique (37°40'S, 59°23'W; 210 m elevation), Benito Juárez county, Buenos Aires province, Argentina. This region is dominated by agroecosystems and introduced woodlands. The original vegetation (herbaceous steppe) has been reduced to small remnant patches in areas where agriculture is not feasible. The weather is temperate, with an annual mean temperature of 13.3°C and annual mean precipitation of 775 mm, concentrated during the summer (Jauregui and Bernabé 1987).

We collected 77 fresh pellets and the remains of one prey from three pairs of White-tailed Kites. For Barn Owls, we examined 154 fresh pellets from two pairs. Both samples were collected under nests and roost sites from August–December 1998. Minimum number of prey were determined by skull remains in pellets and identified by comparison with reference material of Museo de La Plata mammal collections. Biomass of prey were estimated by multiplying the number of individuals of each prey species by the mean mass of these prey obtained from literature (Redford and Eisenberg 1992). To compare trophic resources between both raptors, we estimated a standardized niche breadth (Jaksic 2000). This index varies between 0 and 1, and permits comparison between species. Additionally, we used Pianka's index (Marti 1987) to measure trophic overlap. Values of this index vary between 0 (no overlap) and 1 (complete overlap). Finally, we estimated geometric mean prey mass (Marti 1987). This estimation is useful in the comparison of diets among raptors (Marti 1987).

To examine activity period and its relationship with prey consumption, we classified prey and prey percent biomass based on pellet data as available during nocturnal, diurnal, or both periods, based on literature (e.g., Dalby 1975, Massoia 1976, Pearson 1988, Nowak 1999, Pardiñas unpubl. data). We used a chi-squared test to compare the relative proportion of prey in the different periods of activity between species. Geometric mean prey mass was compared among raptors using a *t*-test, after log-transformation to normalize the data (Sokal and Rohlf 1981).

We acknowledge that determination of raptor diets with the analysis of pellets, especially for kites, involves some inherent biases. Specifically, Falconiforms typically digest bone to a greater extent than do owls (Marti 1987, Andrews 1990). Here we offer a preliminary comparison of the diets of these two raptors in the southern Buenos Aires province. We also suggest that additional data should be collected to evaluate the biases of using pellets

¹ E-mail address: lucasleveau@yahoo.com.ar

Table 1. Percent frequency and biomass of small mammals consumed by White-tailed Kite ($N = 109$ prey) and Barn Owl ($N = 448$ prey) in Villa Cacique, Buenos Aires, Argentina.

PREY	PREY MASS (g) ^a	WHITE-TAILED KITE		BARN OWL	
		PERCENT FREQUENCY	PERCENT BIOMASS	PERCENT FREQUENCY	PERCENT BIOMASS
<i>Calomys</i> sp.	14	24.8	11.0	57.1	23.6
<i>Akodon azarae</i>	28	37.6	33.4	25.4	21.0
<i>Oxymycterus rufus</i>	76	8.3	19.9	3.3	7.5
<i>Oligoryzomys flavescens</i>	19	5.5	3.3	4.0	2.2
<i>Holochilus brasiliensis</i>	326	0.0	0.0	2.2	21.4
<i>Reithrodon auritus</i>	79.5	0.0	0.0	2.9	6.8
<i>Necromys benefactus</i>	31	14.7	14.4	1.6	1.4
<i>Mus domesticus</i>	14	0.9	0.4	1.1	0.5
<i>Rattus</i> sp.	320	0.0	0.0	1.1	10.5
<i>Cavia aperea</i> (juvenile)	250	1.8	14.5	0.7	4.9
<i>Monodelphis dimidiata</i>	15	6.4	3.1	0.2	0.1
Chiroptera	11	0.0	0.0	0.2	0.1
		100.0	100.0	100.0	100.0

^a From Redford and Eisenberg (1992).

to assess the diet of White-tailed Kites relative to using this technique for Barn Owls.

RESULTS AND DISCUSSION

For White-tailed Kites, seven taxa of cricetid rodents accounted for more than 90% of 109 individuals consumed, followed by the marsupial (*Monodelphis dimidiata*; 6.4%; Table 1). The most common species taken were *Akodon azarae*, *Calomys* sp., and *Necromys benefactus* (Table 1). Prey mass varied between 14 g (*Calomys* sp., *Mus domesticus*) and 250 g (*Cavia aperea*; juvenile; Table 1). *Akodon azarae*, *Oxymycterus rufus*, *C. aperea*, and *N. benefactus*, in that order, accounted for 82% of the biomass of prey (Table 1).

For Barn Owls, 10 taxa of cricetid rodents were identified from the 448 individuals consumed. *Monodelphis dimidiata* and an unidentified bat were also recorded (Table 1). The most commonly taken species were *Calomys* sp. and *A. azarae*, representing more than 80% of the prey consumed (Table 1). Prey mass varied between 11 g (Chiroptera) and 326 g (*Holochilus brasiliensis*; Table 1). *Calomys* sp., *A. azarae*, and *H. brasiliensis* accounted for 66% of the biomass of prey, in that order of importance (Table 1).

Standardized niche breadths were 0.45 and 0.14 for White-tailed Kites and Barn Owls, respectively. The greater breadth for White-tailed Kites was due to the inclusion of *A. azarae*, *Calomys* sp., and *N. benefactus*, while Barn Owls preyed mainly on *Calomys* sp. (Table 1).

Pianka's index was 0.80, indicating a substantial trophic overlap between the two raptors. Simeone (1995), who studied the diet of White-tailed Kites and Barn Owls in Chile, also found overlap values ranging from 0.87–0.96. In our study, the high trophic overlap might be

related to several factors acting singly or in combination. (1) both raptors share the same hunting habitats, mainly harvested wheat fields and pasture fields (L. Leveau and C. Leveau unpubl. data); (2) the prey resources (small mammals) may be very abundant and, therefore, easily available to both raptors; and (3) these resources (small mammals) are available both during the day and night, the activity periods of hawks and owls, respectively. According to Jaksic (1982), diurnal and nocturnal raptors could share the same trophic resources by extending their hunting activities to crepuscular hr, "sharing" the prey of that activity period.

Prey frequencies and percent of prey biomass differed significantly in relation to period of activity (Fig. 1; $\chi^2 = 135.15$ and 133.27 , respectively; $df = 2$; $P < 0.001$). White-tailed Kites consumed a larger proportion of diurnal mammals, such as *M. dimidiata*, *N. benefactus*, and *O. rufus* (Fig. 1a). On other hand, Barn Owls consumed more rodents that were exclusively nocturnal, such as *Calomys* sp., *H. brasiliensis*, and *R. auritus* (Fig. 1a). Prey biomass showed a similar trend (Fig. 1b).

Geometric mean of prey body mass for White-tailed Kites (25.27 ± 3.26 g) was greater than that of Barn Owls (21.57 ± 2.8 g; $t = 2.15$, $df = 555$, $P = 0.032$). White-tailed Kites ate rodents that were heavier (*N. benefactus* 31 g and *O. rufus* 76 g), than the most frequent prey taken by Barn Owls (*Calomys* sp. 14 g; Table 1). While both raptors have almost the same body mass, White-tailed Kite seemed to be more effective at capturing larger rodents or, alternatively, prey such as *N. benefactus* and *O. rufus* could be more abundant during the day. *Oxymycterus rufus* shows peaks of activity between 0800–1000 H and 1400–1900 H in southern Buenos Aires province

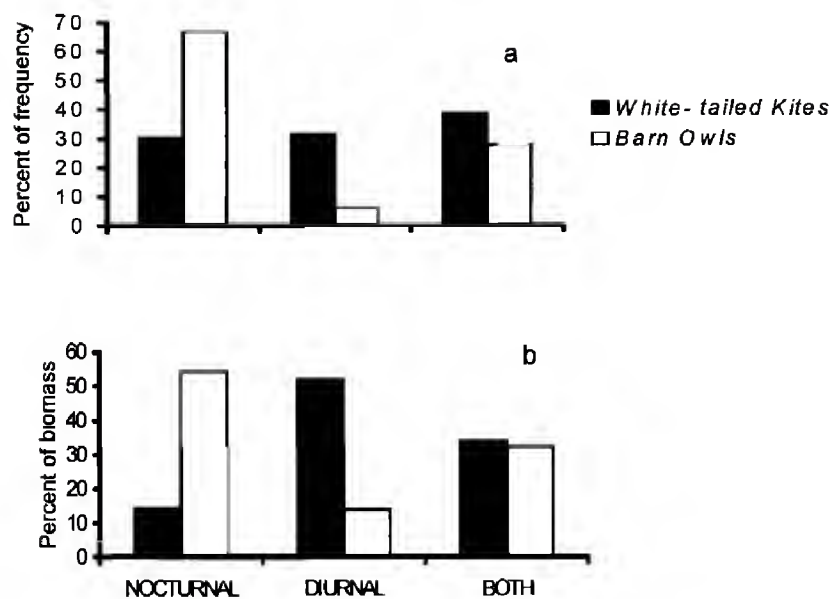


Figure 1. Distribution of prey frequency (a) and prey biomass (b) based on activity periods of rodents consumed by White-tailed Kites and Barn Owls in Villa Cañique.

(U. Pardiñas unpubl. data). This pattern of diurnal activity could explain the low abundance of this species in several analyses of the Barn Owl diet (Pardiñas 1999).

Although both raptors will select their prey in accordance to their period of activity, a trophic overlap of 80% suggests potential competition for food when in short supply (Simeone 1995). If prey were in ample supply, then the large trophic overlap may be interpreted as opportunistic convergence on abundant resources. However, the diurnal hunting activity of White-tailed Kites and the nocturnal activity of Barn Owls probably results in the avoidance of interference interactions (Case and Gilpin 1974, Marti and Kochert 1995, Simeone 1995). Similarly, White-tailed Kites nest in trees (de la Peña 1992), while Barn Owls nest mainly in cavities of buildings (de la Peña 1994), in this way avoiding competition for nest sites. The dietary similarity of these two species in the southern part of the Buenos Aires province might indicate that both raptors are dietary counterparts, consuming the same trophic resources alternatively during the day and night (Jaksic et al. 1981, Jaksic 1983, Simeone 1995).

RESUMEN.—Se compararon los mamíferos ingeridos por dos conocidos especialistas en el consumo de roedores, el milano blanco (*Elanus leucurus*) y la lechuza de campanario (*Tyto alba*), en el sur de la provincia de Buenos Aires, Argentina. Ambas rapaces depredaron casi exclusivamente sobre roedores cricétidos. Los valores de amplitud de nicho trófico estandarizado para el milano blanco y la lechuza de campanario fueron de 0.45 y 0.14, respectivamente. El solapamiento trófico entre las dos rapaces, basado en el índice de Pianka, fue del 80%. Los roedores de actividad diurna fueron más frecuentes y aportaron mayor biomasa en la dieta del milano blanco. El mismo patrón fue observado en la dieta de la lechuza de campanario, pero en relación con roedores funda-

mentalmente nocturnos. El peso promedio de las presas fue significativamente mayor en la dieta del milano que en la de la lechuza. El alto grado de solapamiento trófico podría estar indicando potencial competencia entre las dos especies.

[Traducción de los autores]

ACKNOWLEDGMENTS

P. Timo, J. Valero, D. Retondo, A. Leveau, C. Leveau, and R. Schlatter helped in many ways. M.I. Bellocq and F. Jaksic, three anonymous referees, and the editor gave critical comments on the manuscript. We really appreciate the improvements in English usage made by James Roper through the Association of Field Ornithologists' program of editorial assistance. This research was supported by a scholarship from the Fundación Antorchas (LML and CML) and funds from the Consejo Nacional de Investigaciones Científicas y Técnicas (UFJP).

LITERATURE CITED

- ANDREWS, P. 1990. Owls, caves, and fossils. Predation, preservation, and accumulation of small mammal bones in caves, with an analysis of the Pleistocene Cave faunas from Westbury-sub-Mendip, Somerset, U.K. Univ. of Chicago Press, Chicago, IL U.S.A.
- BELLOCQ, M.I. 2000. A review of the trophic ecology of the Barn Owl in Argentina. *J. Raptor Res.* 34:108–119.
- CASE, T.J. AND M.E. GILPIN. 1974. Interference competition and niche theory. *Proc. Nat. Acad. Sci.* 71:3073–3077.
- CODY, M.L. 1968. On the methods of resource division in grassland birds communities. *Am. Nat.* 102:107–147.
- DALBY, P.L. 1975. Biology of Pampa rodents, Balcarce Area, Argentina. *Publ. Mus. Mich. State Univ. Biol. Ser.* 5:149–272.
- DE LA PEÑA, M.R. 1992. Guía de aves argentinas. Tomo 2, Falconiformes, Galliformes, Gruiformes, Charadriiformes. Edición L.O.L.A., Buenos Aires, Argentina.
- . 1994. Guía de aves argentinas. Tomo 3, Columbiformes, Psittaciformes, Cuculiformes, Strigiformes, Caprimulgiformes, Apodiformes, Trogoniformes, Coraciformes, Piciformes. Editorial L.O.L.A., Buenos Aires, Argentina.
- DEL HOYO, J., A. ELLIOTT, AND J. SARGATAL (EDS.). 1999. Handbook of birds of the world. Vol. 5: Barn Owls to Hummingbirds. Lynx Edicions, Barcelona, Spain.
- JAKSIC, F.M. 1982. Inadequacy of activity time as a niche difference: the case of diurnal and nocturnal raptors. *Oecologia* 52:171–175.
- . 1983. The trophic structure of sympatric assemblages of diurnal and nocturnal birds of prey. *Amer. Midl. Nat.* 109:152–162.
- . 1988. Trophic structure of some Nearctic, Neotropical and Palearctic owl assemblages: potential roles of diet opportunism, interspecific interference and resource depression. *J. Raptor Res.* 22:44–52.
- . 2000. Ecología de comunidades. Ediciones Universidad Católica de Chile, Santiago, Chile.

- , H.W. GREENE, AND J.L. YAÑEZ. 1981. The guild structure of a community of predatory vertebrates in Central Chile. *Oecologia* 49:21–28.
- , R. ROZZI, A. LABRA, AND J.E. JIMÉNEZ. 1987. The hunting behavior of Black-shouldered Kites (*Elanus caeruleus leucurus*) in central Chile. *Condor* 89:907–911.
- , J.E. JIMENEZ, S.A. CASTRO, AND P. FEINSIGER. 1992. Numerical and functional response of predator to a long-term decline in mammalian prey at semi-arid Neotropical site. *Oecologia* 89:90–101.
- JAUREGUY, J. AND M.A. BERNABÉ. 1987. Estudio preliminar de ubicación de un área industrial cercana a las localidades de Barker y Villa Cacique. Munic. Benito Juárez, U.N.C.P.B.A. y C.I.C, Tandil, Argentina.
- LEVEAU, L.M., C.M. LEVEAU, AND U.F.J. PARDIÑAS. 2002. Dieta del Milano Blanco (*Elanus leucurus*) en Argentina. *Ornitol. Neotrop.* 13:507–511.
- MARTI, C.D. 1987. Raptor food habits studies. Pages 67–80 in B. Giron-Pendleton, B.A. Millsap, K.W. Cline, and D.M. Bird [EDS.], Raptor management techniques manual. Nat. Wildl. Fed., Washington, DC U.S.A.
- AND M.N. KOCHERT. 1995. Are Red-tailed Hawks and Great Horned Owls diurnal-nocturnal counterparts? *Wilson Bull.* 107:615–628.
- MASSOIA, E. 1976. Mammalia. Pages 7–127 in R. Ringuelet [ED.], Fauna de Agua Dulce de la República Argentina. Fundación Editorial Ciencia y Cultura, Buenos Aires, Argentina.
- MENDELSON, J.M. AND F.M. JAKSIC. 1989. Hunting behavior of Black-shouldered Kites in the Americas, Europe, Africa and Australia. *Ostrich* 60:1–12.
- MESERVE, P.L. 1977. Food habits of a White-tailed Kite population in central Chile. *Condor* 79:263–265.
- NAROSKY, T. AND A.G. DI GIACOMO. 1993. Las aves de la Provincia de Buenos Aires: Distribución y Estatus. Asoc. Ornitológica del Plata, Buenos Aires, Argentina.
- AND D. YZURIETA. 1987. Guía para la identificación de las aves de Argentina y Uruguay. Asoc. Ornitol. del Plata, Buenos Aires, Argentina.
- NOWAK, R.F. 1999. Walker's mammals of the world. Johns Hopkins Univ. Press, Baltimore, MD U.S.A.
- PARDIÑAS, U.F.J. 1999. Los roedores muroideos del Pleistoceno tardío-Holoceno en la región pampeana (sector este) y Patagonia (República Argentina): aspectos taxonómicos, importancia bioestratigráfica y significación paleoambiental. Dissertation, Facultad de Ciencias Naturales y Museo, Univ. Nacional La Plata, La Plata, Argentina.
- AND S. CIRIGNOLI. 2002. Bibliografía comentada sobre los análisis de egagrópilas de aves rapaces en Argentina. *Ornitol. Neotrop.* 13:31–59.
- PEARSON, O.P. 1988. Biology and feeding dynamics of a South American herbivorous rodent, *Reithrodon*. *Stud. Neotrop. Fauna Environ.* 23:25–39.
- REDFORD, K.H. AND J.F. EISENBERG. 1992. Mammals of the neotropics, the southern cone: Chile, Argentina, Uruguay, Paraguay. Vol. 2. Univ. Chicago Press, Chicago, IL U.S.A.
- SCHLATTER, R.P., H.J. TORO, J.L. YAÑEZ, AND F.M. JAKSIC. 1980. Prey of the White-tailed Kite in central Chile and its relationship to the hunting habitat. *Auk* 97:186–190.
- SCHOENER, T.W. 1974a. Resource partitioning in ecological communities. *Science* 185:27–39.
- . 1974b. The compression hypothesis and temporal resource partitioning. *Proc. Nat. Acad. Sci.* 71:4169–4172.
- SIMEONE, A.C. 1995. Ecología trófica del bailarín *Elanus leucurus* y la lechuza *Tyto alba* y su relación con la intervención humana en el sur de Chile. Tesis de Licenciatura, Universidad Austral de Chile, Valdivia, Chile.
- SOKAL, R.R. AND F.J. ROHLF. 1981. Biometry. Freeman, San Francisco, CA U.S.A.

Received 6 May 2003; accepted 27 November 2003

J. Raptor Res. 38(2):181–186

© 2004 The Raptor Research Foundation, Inc.

RELATIVE ABUNDANCE AND DIVERSITY OF WINTER RAPTORS IN SPOKANE COUNTY, EASTERN WASHINGTON

HOWARD L. FERGUSON¹

Washington Department of Fish & Wildlife, North 8702 Division Street, Spokane, WA 99218 U.S.A.

KEY WORDS: *Red-tailed Hawk*; *Buteo jamaicensis*; *Rough-legged Hawk*; *Buteo lagopus*; *relative abundance*; *roadside survey*; *sympatry*; *winter distribution*.

¹ E-mail address: ferguhl@dfw.wa.gov

For years, biologists, falconers, and bird-watchers have recognized the high density of raptors in eastern Washington during the winter. Discussions with observers throughout the region indicate this zone of high abundance may extend from eastern Washington, east to the

Boise area, Idaho, and south into Utah. Underscoring the importance of identifying and quantifying this zone of potentially high raptor abundance is the rapid human population growth occurring in this same region. The mean growth rate in eastern Washington is 19.1%, with some counties recording growth rates of 35–36%. Boise, Idaho experienced a phenomenal growth rate of 46.1% (U.S. Census Bureau 2001). For effective land use planning, quantitative biological data are required. Such data are also required to design and implement long-range, year-round, landscape-level raptor conservation strategies (Sherry and Holmes 1995). Local governments in eastern Washington are just beginning to develop growth management policies in an attempt to preserve and protect the native wildlife as the human population continues to expand into formerly rural land and wildland. Data on the abundance and ecology of the local wildlife is necessary to help establish these policies. In order to verify and quantify the high winter raptor densities in eastern Washington, a 3-yr study was conducted in eastern Washington from 1995–98.

Road counts were employed because one of the objectives of this study was to compare the results of this survey to other winter raptor studies in the western U.S. Although the reliability of road counts has been questioned (Millsap and LeFranc 1988) due to several inherent biases (e.g., species detectability, perch availability, along roads, weather, variation in observer expertise) this approach can be effective in assessing relative abundance and long-term trends over large areas, particularly in more open habitats (Millsap and LeFranc 1988, Province of British Columbia 2001, Hutto and Young 2002). In addition, recommended standardized guidelines were followed when conducting the surveys (e.g., Andersen et al 1985, Bildstein 1987, Fuller and Mosher 1987, Andersen and Rongstad 1989).

STUDY AREA

The study was in Spokane County in eastern Washington near the border of Idaho (Fig. 1). Spokane County has ca. 250 000 people in urban areas, and 200 000 in nonurban areas (Washington Office of Financial Management 1998). Spokane County is dominated by Ponderosa Pine (*Pinus ponderosa*) and Palouse (steppe) vegetation zones (Cassidy 1997; Fig. 1). Much of the county consists of a transition zone ranging from the arid Columbia Basin shrub-steppe region in the southwest corner to the mixed evergreen forests of the Selkirk-Rocky Mountain complex in the northeast corner.

METHODS

I conducted 120 roadside surveys on five different routes (24 surveys of each route) for three consecutive winters covering ca. 2510 km of secondary roads. These five routes were located on secondary roads outside the city of Spokane that had low traffic volumes, sufficient shoulder width for stopping, and scheduled snow removal (Fig. 1). The lengths of the five survey routes were 28.9, 27.3, 22.5, 12.1, and 13.7 km for Big Meadows

(BM), Coulee Hite (CH), Hangman Valley (HV), Little Spokane (LS) and Saltese Flats (SF) routes, respectively. Three of the routes (BM, CH, HV) traversed multiple habitats including agricultural, mixed evergreen forests dominated by ponderosa pine, and riparian areas. The LS route followed a riparian corridor containing a mix of cottonwood (*Populus balsamifera*), Douglas-fir (*Pseudotsuga menziesii*) and ponderosa pine. The SF route included lowland with emergent wetlands surrounded by ponderosa pine, native bunchgrass steppe, and some agriculture. Each of the five routes was surveyed six times during the winter of 1995–96 and 9 times each of the 2 subsequent winters, 1996–97 and 1997–98. The routes were sampled starting 15 November ending 15 March. The direction and order in which transects were driven were varied and conducted throughout the day to minimize temporal biases. All surveys were conducted between 0800–1600 H at vehicle speeds of 40 km/hr or less. Occasional brief stops (<2 min) were made to identify and to record observed raptors. Surveys were not conducted, if weather conditions resulted in restricted vision or if winds were >40 km/hr.

Only raptors initially seen with the unaided eye were recorded. Binoculars (10 × 40 and 8 × 42) were used to aid in identification. Both perched and flying raptors were recorded and mapped, including direction of flight. After first detection, all attempts were made to minimize recounting of raptors by noting previous observations, direction of flight, mapped location, and any comments such as an unusual color phase. Subsequently, if a bird of the same species, phase, age, and sex was observed in the same area as a previously recorded bird, this observation was not recorded.

Because of the small sample size obtained for less common species, most of the results were restricted to the five most common species. Unknown raptors were eliminated from the study results ($N = 7$, <1%). To determine if there were significant time-of-day influences on the number and species of raptors observed, data were categorized two different ways. The first method divided all observations into four time categories: 0800–0959, 1000–1159, 1200–1359, and 1400–1559 H. while the second divided observations into two time periods: morning from 0800–1159 H, and afternoon from 1200–1559 H. Chi-square tests (Sokal and Rohlf 1995) were used to look at the significance of these results. A correction for continuity was made for chi-square tests with only one degree of freedom.

Ten winter raptor studies were selected from the literature that allowed calculation of relative abundance (i.e., number of raptors observed and distance traveled were reported) and were used for comparison to this study (Table 1). All results and analyses were standardized to the distances surveyed. Relative abundance was calculated as the number of birds observed divided by the km surveyed times 1000.

RESULTS

A total of 1205 raptors of 12 different species were recorded. The four most common species were Red-tailed Hawk (*Buteo jamaicensis*; 65%), Rough-legged Hawk (*Buteo lagopus*; 18%), Bald Eagle (*Haliaeetus leucocephalus*; 6%),

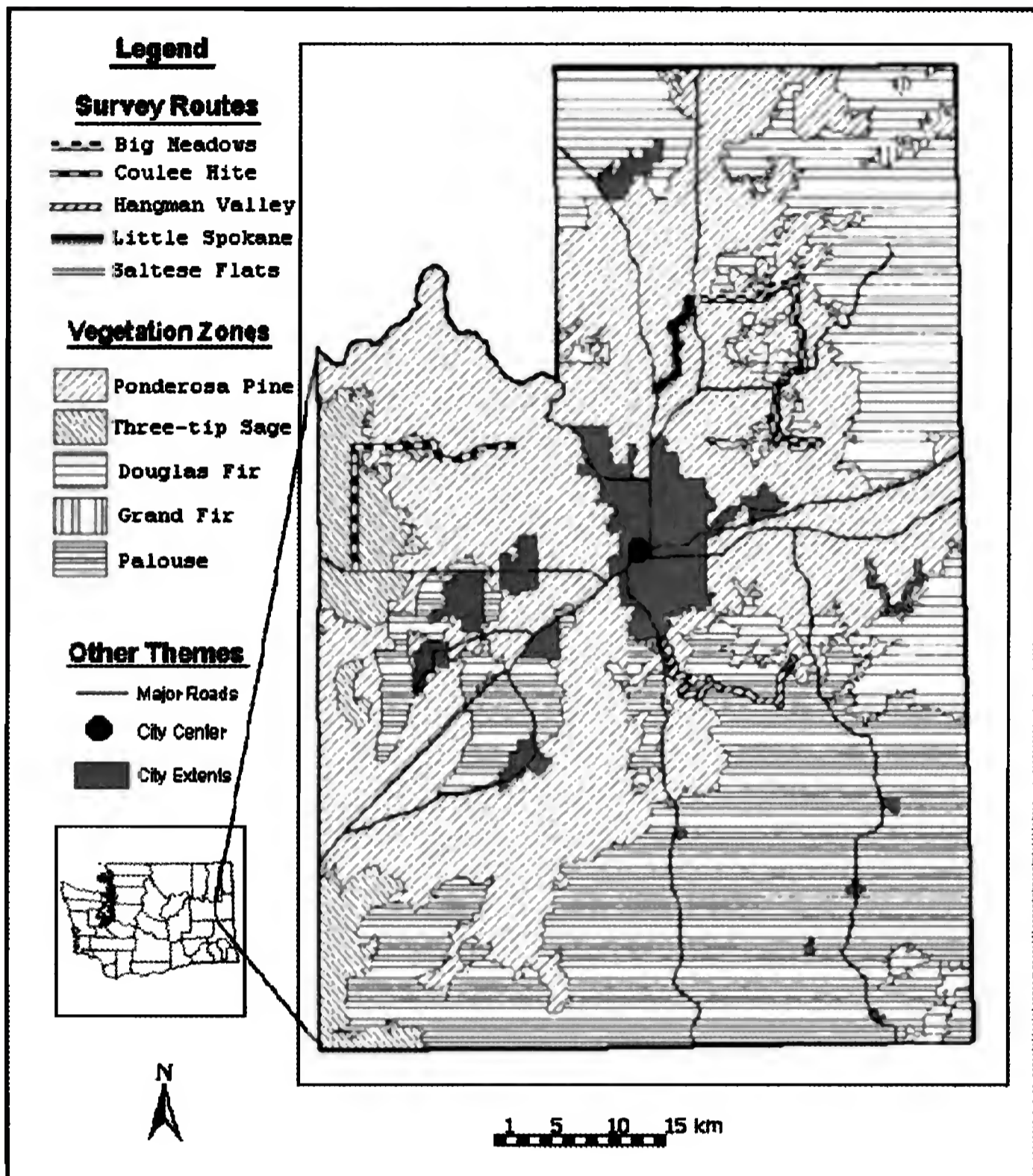


Figure 1. Map of Spokane County, WA, showing study area including raptor road count routes and major vegetation types, 1995-98.

and Northern Harrier (*Circus cyaneus*; 5%; Table 1). American Kestrel (*Falco sparverius*) comprised 3%, two other falcons, Merlin (*F. columbarius*) and Prairie Falcon (*F. mexicanus*) together added 0.5%, Golden Eagle (*Aquila chrysaetos*) less than 0.1%, and all three species of Accipiters, Sharp-shinned Hawk (*Accipiter striatus*), Cooper's Hawk (*A. cooperii*), and Northern Goshawk (*A. gentilis*) comprised an additional 1%. The Great-horned Owl (*Bubo virginianus*) made up 1%. The relative abundance of the predominant five species was 313 for Red-tailed Hawks, 88 for Rough-legged Hawks, 29 for Bald Eagles, 24 for Northern Harriers, and 13 for American Kestrels. Relative abundance for the entire study was 480 raptors (Table 1).

The 65 morning surveys covered ca. 1345 km while the 55 afternoon surveys covered 1165 km. I observed 41% of all raptors in the morning and 58% in the afternoon (Table 1). Significantly more raptors were observed in the afternoon than in the morning ($\chi^2 = 71.38$, $P < 0.001$). Red-tailed Hawks, Rough-legged Hawks, and Northern Harriers were observed more frequently on afternoon surveys than on morning counts ($\chi^2 = 51.66$, 12.78, and 29.78, respectively; all $P < 0.001$).

DISCUSSION

In the Spokane area, I recorded relative abundance of 480 raptors/1000 km, a higher abundance than 10 pre-

Table 1. Morning, afternoon, and total results of raptors observed and their relative abundance during winter in Spokane County, eastern Washington, 15 November–15 March, 1995–98.

	BIRDS OBSERVED					
	MORNINGS		AFTERNOONS		TOTAL	
	NO.	ABUNDANCE ^a	NO.	ABUNDANCE ^a	NO.	ABUNDANCE ^a
Red-tailed Hawk	320	237.9	466	400.0	786	313.1
Rough-legged Hawk	92	68.4	129	110.7	221	88.0
Bald Eagle	38	28.2	34	29.2	72	28.7
Northern Harrier	20	14.9	41	35.2	61	24.3
All other species combined	29	21.5	36	31.0	65	25.9
All species	499	371.0	706	606.0	1205	480.1

^a Relative abundance based on raptors recorded per 1000 km.

vious studies in the western U.S.A. (Table 2). The study with the next highest relative abundance (432) is another Washington study conducted ca. 320 km west of Spokane in Kittitas County (Chestnut and Boomgarden 1997). When evaluated on a landscape level, these two studies suggest high winter raptor abundance throughout the eastern Washington area. The next highest relative abundance values reported were 350 in central Utah (Fischer et al. 1984), and 262 in northern Utah (Brouse 1999). With regard to species diversity, 12 species were observed during the 3-yr study, placing it second in reported richness along with several of the other western studies (Table 2).

Red-tailed Hawks had the highest relative abundance with 313, while Rough-legged Hawks were next highest with 88, a ratio of 3.6 Red-tailed Hawks for each Rough-legged Hawk. Chestnut and Boomgarden (1997) also reported Red-tailed Hawks (290) as the most common species with Rough-legged Hawks (108) being the second most common, a ratio of 2.7.

These unusually high Red-tailed Hawk numbers differ from the other published studies in the more northern and eastern portions of the west. In Colorado and Nebraska, Enderson (1965), Mathisen and Mathisen (1968), and Johnson and Enderson (1972) reported Rough-legged Hawks as the most common *Buteo* on winter roadside counts while Red-tailed Hawks were scarce. Stahldecker and Belke (1974) observed only five Red-tailed Hawks, but observed 108 Rough-legged Hawks in northeastern Colorado. Similarly, Johnson and Enderson (1972) in eastern Colorado recorded only four red-tails, but 107 Rough-legged Hawks. In neighboring Idaho, Craig (1978) found Rough-legged Hawks to be the most numerous wintering raptor, while Red-tailed Hawk numbers were so low they were not reported. On the other hand, studies in the southwestern U.S.A. indicate Red-tailed Hawks predominate. In southeastern Arizona, Parker and Campbell (1984) reported 200 red-tails and only 14 rough-legs. In central California, Smallwood et al. (1996) recorded 822 red-tails and only five Rough-legged Hawks.

Table 2. Relative abundance and species diversity derived from published winter road count raptor studies in the western U.S.A. (some values were calculated from the publ. data).

	LOCATION	RELATIVE ABUNDANCE (RAPTORS/1000 km)	NO. OF SPECIES	TOTAL km TRAVELED
This study	Eastern WA	480.1	12	2510
Chestnut and Boomgarden (1997)	Eastern WA	450.5	11	1445
Fischer et al. (1984)	Central UT	350.0	10	1500
Brouse (1999)	Northern UT	261.9	13	4070
Stahldecker and Belke (1974)	Northeast CO	208.1	8	1312
Johnson and Enderson (1972)	Eastern CO	173.5	9	1677
Marion and Ryder (1975)	Northeast CA	166.7	6	936
Enderson (1965)	Eastern CO	158.0	9	2695
Craig (1978) (Nov–Mar)	Southeast ID	88.7	12	3553
Parker and Campbell (1984)	Southeast AZ	80.5	12	6386
Andersen and Rongstad (1989)	Southeast CO	71.6	12	3407

In contrast to these other studies, my study reveals that eastern Washington has relatively high numbers of both Red-tailed and Rough-legged hawks (Table 1).

This sympatry of Red-tailed and Rough-legged hawks seems to be the unusual feature of the winter raptor population in eastern Washington. I suggest that this zone of high relative abundance with these two species being sympatric extends south into Utah based on two Utah studies of wintering raptors. Brouse (1999) observed 161 red-tails and 55 Rough-legged Hawks, while Fischer et al. (1984) reported 169 red-tails and 78 Rough-legged Hawks, ratios of 2.9 and 2.2 red-tails to rough-legs, respectively. The relative abundance values found in these two studies for red-tails and Rough-legged Hawks were the highest reported next to the two Washington studies. However, more studies need to be conducted, particularly in Idaho, to determine the extent of this zone of sympatry. Craig's (1978) results in southeastern Idaho indicated that Red-tailed Hawks occurred only in low numbers in that region.

In conclusion, eastern Washington is an important wintering area for a large and diverse raptor community. Contributing to this overall abundance is the fact that both Red-tailed Hawks and Rough-legged Hawks are abundant in this area. Although many of these raptors may not nest in the area, they do reside in, and depend upon the area for life support for several months each year. Considering this dependence, it is important to protect and conserve these important wintering areas. Development of conservation strategies for this key wintering area for raptors is particularly important because of growing urban areas, such as Spokane, in this region.

RESUMEN.—Un total de 120 estudios de rapaces al borde de la carretera fueron llevados a cabo en cinco diferentes rutas en el condado Spokane, al oriente de Washington, cubriendo un total de 2510 km de carreteras secundarias durante los inviernos de 1995–98. Cerca de 1200 aves rapaces de 12 especies diferentes fueron registradas durante el periodo de 3 años. Las cuatro especies más comunes. El gavilán de cola roja (*Buteo jamaicensis*; 65% del Total), el gavilán de patas gruesas (*Buteo lagopus*; 18%), el águila calva (*Haliaeetus leucocephalus*; 6%), y el aguilucho norteno (*Circus cyaneus*; 5%), abarcaron casi el 95% de todas las rapaces vistas. La abundancia relativa para todo el estudio fue 480 rapaces por cada 1000 km muestreados. Fueron observadas significativamente más rapaces en la tarde que en la mañana. La comparación de resultados con otros 10 estudios en el occidente indicó que la abundancia relativa de rapaces invernantes en el oriente de Washington fue una de las más altas reportadas para el Oeste. Esta alta abundancia relativa, en parte, parece ser resultado de la simpatria entre los gavilanes de cola roja y los de patas gruesas en el área oriental de Washington.

[Traducción de César Márquez]

ACKNOWLEDGMENTS

I am grateful to Tom Owens for help with the figures, and to Matt Vander Haegen and Jim Watson for their reviews. I would like to thank L. Flake, R. Lehman, and an anonymous referee for providing their helpful comments on earlier drafts of this manuscript.

LITERATURE CITED

- ANDERSEN, D.E., O.J. RONGSTAD, AND W.R. MYTTON. 1985. Line transect analysis of raptor abundance along roads. *Wildl. Soc. Bull.* 13:533–539.
- AND O.J. RONGSTAD. 1989. Surveys for wintering birds of prey in southeastern Colorado 1983–88. *J. Raptor Res.* 23:152–156.
- BILDSTEIN, K.L. 1987. Behavioral ecology of Red-tailed Hawks (*Buteo jamaicensis*), Rough-legged Hawks (*Buteo lagopus*), Northern Harriers (*Circus cyaneus*), and American Kestrels (*Falco sparverius*) in south-central Ohio. Ohio Biol. Surv. Biol. Columbus, OH U.S.A.
- BROUSE, P. 1999. Twenty year change in the raptor community in northern Utah during the nonbreeding season. *J. Raptor Res.* 33:317–322.
- CASSIDY, K.M. 1997. Land cover of Washington State: description and management. Pages 1–260 in K.M. Cassidy, C.E. Grue, M.R. Smith, and K.M. Dvornich [EDS.], Washington State Gap Analysis. Washington Cooperative Fish and Wildlife Research Unit, University of Washington, Seattle, WA U.S.A.
- CHESTNUT, T. AND K. BOOMGARDEN. 1997. Abundance, distribution, and habitat associations of raptors wintering in the Kittitas Valley, Kittitas County, Washington. Poster Presentation, Joint Meeting of Society for Northwestern Vertebrate Biology and The Wildlife Society, Yakima, WA U.S.A.
- CRAIG, T.H. 1978. A roadside raptor survey of raptors in southeastern Idaho 1974–76. *Raptor Res.* 12:40–45.
- ENDERSON, J.H. 1965. Roadside raptor count in Colorado. *Wilson Bull.* 77:82–83.
- FISCHER, D.L., K.L. ELLIS, AND R.J. MEESE. 1984. Winter habitat selection of diurnal raptors in central Utah. *Raptor Res.* 18:98–102.
- FULLER, M.R. AND J.A. MOSHER. 1987. Raptor Survey Techniques. Pages 37–65 in B.A. Giron Pendleton, B.A. Millsap, K.W. Cline, and D.M. Bird [EDS.], Raptor Management Techniques Manual. Natl. Wildl. Fed., Washington, DC U.S.A.
- HUTTO, R.L. AND J.S. YOUNG. 2002. Regional landbird monitoring: perspectives from the Northern Rocky Mountains. *Wildl. Soc. Bull.* 30:738–750.
- JOHNSON, D. AND J.H. ENDERSON. 1972. Roadside raptor census in Colorado-winter 1971–72. *Wilson Bull.* 84:489–490.
- MARION, W.R. AND A. RYDER. 1975. Perch-site preferences of four diurnal raptors in northeastern Colorado. *Condor* 77:350–352.
- MATHISEN, J.E. AND A. MATHISEN. 1968. Species abun-

- dance of diurnal raptors in the panhandle of Nebraska. *Wilson Bull.* 80:479–486.
- MILLSAP, B.A. AND M.N. LEFRANC, JR. 1988. Road transect counts for raptors: how reliable are they? *J. Raptor Res.* 22:8–16.
- PARKER, R.E. AND E.G. CAMPBELL. 1984. Habitat use by wintering birds of prey in southeastern Arizona. *West. Birds* 15:175–183.
- PROVINCE OF BRITISH COLUMBIA. 2001. Inventory Methods for Raptors. Standards for Components of British Columbia's Biodiversity No. 11. Ministry of Sustainable Resource Management Environment Inventory Branch for the Terrestrial Ecosystems Task Force Resources Inventory Committee. Victoria, BC Canada.
- SHERRY, T.W. AND R.T. HOLMES. 1995. Summer versus winter limitation of populations: what are the issues, what is the evidence. Pages 85–120 in T.E. Martin and D.M. Finch [EDS.], *Ecology and management of neotropical migratory birds: a synthesis and review of the critical issues*. Oxford Univ. Press, Oxford, U.K.
- SMALLWOOD, S.K., B.J. NAKAMOTO, AND S. GENG. 1996. Association analysis of raptors on a farming landscape. Pages 177–190 in D. Bird, D. Varland, and J. Negro [EDS.], *Raptors in human landscapes*. Raptor Research Foundation, Academic Press, Ltd., San Diego, CA U.S.A.
- SOKAL, R.R. AND F.J. ROHLF. 1995. *Biometry: the principles and practice of statistics in biological research*. W.H. Freeman and Company, New York, NY U.S.A.
- STAHLDECKER, D.W. AND T.E. BELKE. 1974. Winter diurnal raptor populations of three habitat types in north-eastern Colorado. *Colo. Field Ornithol.* 20:6–17.
- U.S. CENSUS BUREAU. 2001. United States Census 2000. U.S. Department of Commerce Economics and Statistics Administration, <http://www.census.gov>.
- WASHINGTON OFFICE OF FINANCIAL MANAGEMENT. 1998. Population trends. Washington Office of Financial Management, Olympia, WA U.S.A.

Received 3 February 2003; accepted 10 December 2003

J. Raptor Res. 38(2):186–189

© 2004 The Raptor Research Foundation, Inc.

NESTING OF THE WHITE-THROATED HAWK (*BUTEO ALBIGULA*) IN DECIDUOUS FORESTS OF CENTRAL CHILE

EDUARDO F. PAVEZ¹ AND CHRISTIAN GONZÁLEZ

Unión de Ornitólogos de Chile (UNORCH), Casilla 13183, Santiago 21, Chile

BENITO A. GONZÁLEZ

F. Agronomía e Ingeniería Forestal, Pontificia Universidad Católica de Chile, Vicuña Mackenna 4860 Santiago, Chile

CRISTIÁN SAUCEDO

Corporación Nacional Forestal, Ogana 1060, Coyhaique, Chile

SERGIO ALVARADO

Estudios para la Conservación y Manejo de la Vida Silvestre, Blanco Encalada 350, Chillán, Chile

JUAN P. GABELLA AND ALEJANDRA ARNELLO

Unión de Ornitólogos de Chile (UNORCH), Casilla 13183, Santiago 21, Chile

KEY WORDS: *White-throated Hawk*; *Buteo albigula*; *central Chile*; *breeding*; *deciduous forests*.

The White-throated Hawk (*Buteo albigula*; Philippi 1899) is found throughout the Andes mountain range, from northwestern Venezuela through southern Chile and southwestern Argentina (Brown and Amadon 1968). In Chile, the species has been considered an all-year res-

ident between the latitudes of 27° and 40°S (Goodall et al. 1957), a local migrant (Zalles and Bildstein 2000), or its residency status was unknown (Jaksic and Jiménez 1986). Pavez (2000) presented the first evidence of migratory movements. He reported its presence in Chile only during the breeding season (i.e., between September and April), inhabiting high-elevation *Nothofagus* forests (Olrog 1979, Navas and Manghi 1991, Casas and Gelain 1995, Pavez 2000).

Information on the species' breeding biology is scant

¹ E-mail address: eduardopavez@hotmail.com

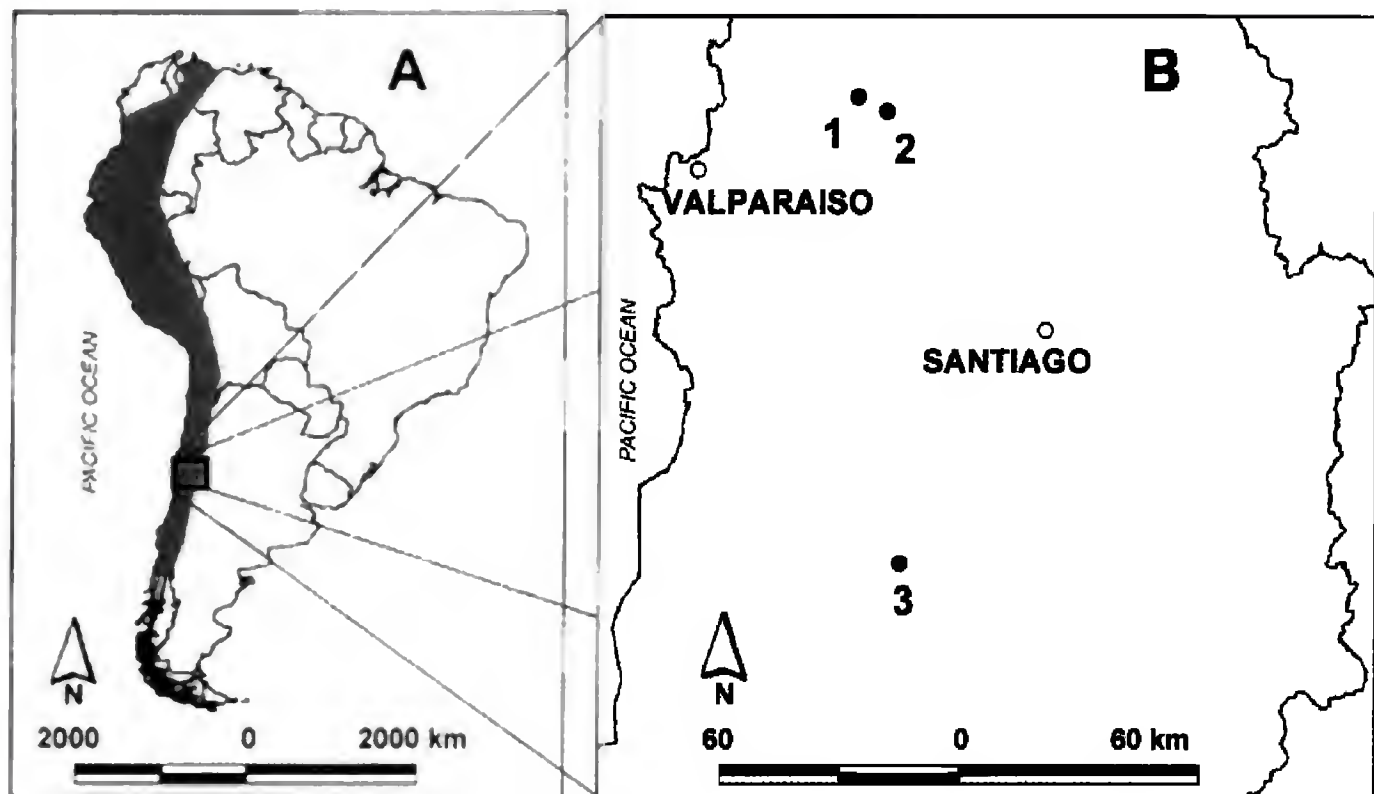


Figure 1. Distribution map of White-throated Hawks (*Buteo albigula*) in South America (A) and the locations in central Chile where observations of this species were noted in this study (B): La Campana National Park (1), Cerro El Roble (2), and Altos de Cantillana (3).

(del Hoyo et al. 1994). According to de la Peña (1992), the White-throated Hawk nests in trees, laying two to three eggs. Recent data have been provided on two nesting pairs in a lenga forest (*Nothofagus pumilio*) by Trejo et al. (2001) and on a larger sample of breeding White-throated Hawks in northwest Argentinean Patagonia, 900 km south of central Chile, by Trejo et al. (2004). In Chile, only one documented breeding record exists, corresponding to a nest on a coastal cliff near Tongoy, in north central Chile (30°25'S, 71°50'W; Goodall et al. 1957). This is the northernmost nesting site recorded for the species. In order to contribute to our knowledge of this rare and poorly-known neotropical raptor, we present information on its nesting and breeding behavior in central Chile.

A pair of White-throated Hawks, which we presumed to be the same individuals, was observed over three consecutive breeding seasons. In spring (4 October 1998), we found an occupied White-throated Hawk nest at La Campana National Park (32°58'S, 71°07'W, 300–1900 m above sea level) on the coastal chain of mountains in central Chile (Fig. 1). The nest site was located at an altitude of 1200 m, on a south facing slope in a native forest dominated by southern beech (roble) trees (*Nothofagus macrocarpa*). The nest, which was nearly 1-m in diameter, was found on the top of a 25 m tall evergreen peumo tree (*Cryptocarya alba*) and located 50 m away from a secondary park road. As reported by Gelain et al. (2001), tourism and cars did not seem to affect the nesting behavior of this pair.

The nesting pair reared one chick that left the nest in summer (January 1999). The nest was reused the follow-

ing spring (October 1999) and the birds reared another chick, which again fledged in summer (January 2000). Also, on 6 October 2000 we observed a pair flying around the same nest, and a juvenile White-throated Hawk was recorded flying over the breeding territory near that nest on 11 March 2001. Plumage color of that juvenile was similar to the 2.5-mo-old dead bird described by Ojeda et al. (2003).

Deliveries of materials to the nest and courtship flights with constant vocalizations were observed during the pre-laying period (15 hr of observations). Two copulations were recorded in spring (2 October 1999 and 6 October 2000). Six prey deliveries to the nest by the male were witnessed during the brood-rearing period (21 hr of observation). Two reptiles (a Chilean racerunner [*Callopistes palluma*] and a lemniscated lizard [*Liolaemus lemniscatus*]), three birds (an Austral Thrush [*Turdus falcklandii*], and what appeared to be one Fire-eyed Diucon [*Xolmis pyrope*], and one White-crested Elaenia [*Elaenia albiceps*]), and an unidentified rodent were consumed by chicks. Although the forest floor under the nest was searched thoroughly, no prey remains nor pellets were found. A young hawk was recorded flying around the nest close to the adult female at the end of the summer (3 hr of observation on 11 March 2000).

Adult White-throated Hawks were detected three times in the area during the breeding season. One of them, an adult male, flew ca. 300 m from the known nest, but the male of the pair did not show any aggressive display toward the "intruder." This suggested that other pairs likely nested in the area.

No hawks were recorded in the study area during the

nonbreeding season (28 hr of observations between April and August 1999). This coincides with the findings of Pavez (2000) regarding the timing of the migratory movements (i.e., departure from the breeding territory in April).

Other records also help establish the dates of the breeding season in the coastal mountains of central Chile. An adult hawk was recorded in early spring (29 September 1997) perched in a well-developed forest on El Roble hill (32°59'S, 70°59'W), located 10-km southeast of La Campana hill. This observation corresponds to the earliest White-throated Hawk record for the breeding season in the area. A pair of White-throated Hawks that had established their territory in a roble-forest stand (*Nothofagus macrocarpa*) at an altitude of 1600–1850 m in the mountains of Loncha, in the area of Altos de Cantilana (34°06'S, 70°59'W) was recorded during October 2000. This site is part of the same coastal mountain range as La Campana, but is located ca. 125-km further south (Fig. 1).

Our observations agree with Pavez (2000) and Trejo et al. (2001) in relation to the characteristics of the breeding habitat (i.e., *Nothofagus* forests in mountainous areas). This, in addition to other records made in the El Roble hill area by J. Jiménez (pers. comm.), who observed a female displaying breeding behavior in *Nothofagus macrocarpa* forest, suggests that in central Chile the few native mountainous forest areas located in the coastal mountain range in La Campana and El Roble hills could be a primary breeding area for this hawk. These habitats are located on the top of the coastal mountain range, between 33° and 34°S latitude, in a narrow and discontinuous north-south corridor ca. 125 km in length. Nevertheless, additional sampling in exotic forests would be necessary in order to know whether this hawk may also breed in disturbed habitat. Considering the known habitat and that cliff nesting by this species has not been confirmed, we believe that it is unlikely for White-throated Hawks to nest on coastal cliffs, such as was reported by Goodall et al. (1957), at a site near Tongoy (30°20'S).

Given the high rate of destruction of deciduous native forests of central Chile (Lara et al. 1995), the breeding habitat of the White-throated Hawk in its northern breeding range is threatened (Jaksic et al. 2001). Furthermore, this species is considered rare and deserves more conservation attention (Jaksic and Jiménez 1986). Special attention should be given to those protected areas that have *Nothofagus* forest, which may be essential for successful breeding by this hawk. Also, the creation of new protected areas with suitable habitat in central Chile could have a positive impact.

Our data revealed this hawk's breeding phenology in central Chile. In September, the birds arrive, probably from the northern Andes (Pavez 2000), on their breeding territories and repair the nests. Copulation and laying occur in October and chick-rearing occurs from November–January. After fledging, the juveniles remain with the

parents in the breeding territory, and then disperse at the end of March and the beginning of April. Our data agree with Trejo et al. (2004) about the duration of each breeding stage in Chile, but the breeding period is slightly earlier than in Argentinean Patagonia. This sequence matches the breeding behavior described for other migratory accipiters, including a short stay by the juvenile on the parents' territory followed by the departure of adults and juveniles from the breeding territory on about the same date (Newton 1979).

RESUMEN.—Aquí presentamos los resultados de observaciones sobre una pareja de aguilucho chico (*Buteo albigula*) durante tres períodos reproductivos sucesivos en Chile central. La pareja utilizó el mismo nido durante todo el estudio. El nido se ubicó en un bosque dominado por robles (*Nothofagus macrocarpa*), en la ladera de un cerro a 1200 m de altitud, criando un pollo por estación reproductiva. La conducta reproductiva siguió un patrón esperable para buteos. Se observó actividad de otros aguiluchos en el área. No se observó presencia de aguiluchos fuera del período reproductivo, lo que se explicaría por su carácter migratorio. Nuestras observaciones indican que los bosques de *Nothofagus*, son el hábitat usado para la reproducción de esta especie en Chile central
[Traducción de los autores]

ACKNOWLEDGMENTS

We thank Cipriano Núñez and the rangers of the Chile's Forest Service (Corporación Nacional Forestal) from the Granizo office, La Campana National Park, who allowed us access to the study area. We thank Cristián Estades, Jaime Jiménez, Javier Simonetti, David Ellis, and anonymous reviewers for commenting on the manuscript. Jerry Laker and Ros Clubb for improving the English version and Magdalena Bennett for drawing the map.

LITERATURE CITED

- BROWN, L. AND D. AMADON. 1968. Eagles, hawks and falcons of the World. Vol. I. McGraw Hill, New York, NY U.S.A.
- CASAS, A. AND M. GELAIN. 1995. Nuevos datos acerca del estatus del aguilucho andino *Buteo albigula* en la Patagonia Argentina. *Hornero* 14:40–42.
- DE LA PEÑA, M. 1992. Guía de las aves Argentinas. Tomo II. Literature of Latin America, Buenos Aires, Argentina.
- DEL HOYO, J., A. ELLIOTT, AND J. SARGATAL (EDS.). 1994. Handbook of the birds of the world. Vol. 2. Lynx Edicions, Barcelona, Spain.
- GELAIN, M., V. OJEDA, A. TREJO, L. SYMPSON, G. AMICO, AND R. VIDAL-RUSSELL. 2001. Nuevos registros de distribución y nidificación del aguilucho andino (*Buteo albigula*) en la Patagonia Argentina. *Hornero* 16:85–88.
- GOODALL, J.D., A.W. JOHNSON, AND R.A. PHILIPPI. 1957. Las aves de Chile, su conocimiento y sus costumbres,

- Tomo II. Platt Establecimientos Gráficos, Buenos Aires, Argentina.
- JAKSIC, F.M. AND J.E. JIMÉNEZ. 1986. The conservation status of raptors in Chile. *Birds of Prey Bull.* 3:95–104.
- , E.F. PAVEZ, J.E. JIMÉNEZ, AND J.C. TORRES-MURA. 2001. The conservation status of raptors in the Metropolitan Region, Chile. *J. Raptor Res.* 35:151–158.
- LARA, A., C. DONOSO, AND J.C. ARAVENA. 1995. La conservación del bosque nativo en Chile: problemas y desafíos. Pages 335–362 in J. Armesto, C. Villagrán, and M.K. Arroyo [EDS.], *Ecología de los bosques nativos de Chile*, Ed. Universitaria, Santiago, Chile.
- NAVAS, J. AND M. MANGHI. 1991. Notas sobre *Buteo ventralis* y *Buteo albigula* en la Patagonia Argentina (Aves, Accipitridae). *Rev. Mus. Argent. Cienc. Nat. Zool.* 15:87–94.
- NEWTON, I. 1979. Population ecology of raptors. T. & A.D. Poyser, London, U.K.
- OJEDA, V., M. GELAIN, L. SYMPSON, AND A. TREJO. 2003. Desarrollo morfológico y conductual de pollos de aguilucho chico *Buteo albigula* (Aves: Accipitridae) en le noroeste de la Patagonia Argentina. *Rev. Chil. Hist. Nat.* 76:451–457.
- OLROG, C. 1979. Nueva lista de la avifauna Argentina. Fund. Miguel Lillo, Tucumán, Argentina.
- PAVEZ, E. 2000. Migratory movements of the White-throated Hawk (*Buteo albigula*) in Chile. *J. Raptor Res.* 34:143–147.
- PHILIPPI, R. A. 1899. *Anales de la Universidad de Chile* 103:664.
- TREJO, A., V. OJEDA, AND L. SYMPSON. 2001. First nest records of the White-throated Hawk (*Buteo albigula*) in Argentina. *J. Raptor Res.* 35:169–170.
- , V. OJEDA, L. SYMPSON, G., AND M. GELAIN. 2004. Breeding biology and nest characteristics of the White-throated Hawk (*Buteo albigula*) in northwestern Argentine Patagonia. *J. Raptor Res.* 38:314–321.
- ZALLES, J.I. AND K.L. BILDSTEIN (EDS.). 2000. Raptor watch: a global directory of raptor migration sites. BirdLife International, Cambridge, U.K. and Hawk Mountain Sanctuary, Kempton, PA U.S.A.

Received 20 May 2003; accepted 9 February 2004

LETTERS

J Raptor Res. 38(2):190–191

© 2004 The Raptor Research Foundation, Inc.

OBSERVATION OF THE CHIMANGO CARACARA (*MILVAGO CHIMANGO*) FEEDING ON COMMON LESSER TOADS (*BUFO FERNANDEZAE*)

The Chimango Caracara (*Milvago chimango*) is a member of Falconidae that occurs throughout southern South America: Argentina, Chile, Uruguay, Paraguay, and southern Brazil (Olrog 1995, Las Aves Argentinas, Editorial El Ateneo, Buenos Aires, Argentina). Various studies have described the Chimango Caracara as an opportunistic predator and scavenger. Its diet has been reported to include arthropods, gastropods, worms, vertebrates, vegetables, and carrion (Barros Valenzuela 1960, *Rev. Univ.* 44–45:31–37, Nuñez and Yañez 1981, *Not. Mens. Mus. Nac. Hist. Nat. Chile* 25:5–9, Nuñez et al. 1982, *Bol. Mus. Nac. Hist. Nat. Chile* 39:125–130, Cabezas and Schlatter 1987, *An. Mus. Hist. Nat. Valparaíso* 18:131–141).

On 5 November 2001, from a distance of ca. 50 m, we observed a Chimango Caracara feeding upon a dead adult common lesser toad (*Bufo fernandezae*). We made this observation in Los Porteños (34°53'45"S, 58°05'02"W), a suburban region of La Plata city (Buenos Aires Province, Argentina), where land uses include cattle ranching, floriculture, and horticulture. At the time of our observation, the caracara was perched on a fence post 1 m in height, which was located in a pasture. This fence post was situated 20-m south of a small, temporary pond where the common lesser toad breeds (pers. obs.) and ca. 30-m south from the caracara's nest. The nest was in a eucalyptus tree (*Eucalyptus* sp.) located along the edge of the pond. The caracara was pecking at the toad's belly and swallowing pieces torn from the frog's viscera and foreleg muscles. This observation constitutes the first report of the common lesser toad in the Chimango Caracara's diet.

Between September 2001 and February 2002, once a wk, we visited the site and examined the ground around fence posts in a fence line that passed within 200 m of the caracara's nest. During our visits, we frequently saw the caracara perched on this fence line. We found 15 carcasses of the common lesser toad, remains of a Rufous Hornero (*Furnarius rufus*), a mouse (unknown species), and bones of a criolla frog (*Leptodactylus ocellatus*) around these perching sites.

Toad carcasses found at perching sites typically had been eviscerated through a ventral hole. The skeleton and dorsal skin remained intact and in some cases the carcasses were without legs. All toad carcasses found were deposited at the herpetological collection of the Instituto de Limnología Platense "Dr. Raúl A. Ringuelet" under the number ILPLA A 491. Snout-vent length of the toad carcasses averaged 60.1 mm (± 4 mm [SD], range = 55.6–68 mm, $N = 16$).

The common lesser toad, along with other species of *Bufo*, has a very thick and glandular-dorsal skin and two prominent post-cephalic glands in a dorso-lateral position (parotoid glands). These glands secrete substances that are noxious or toxic to some predators (Duellman and Trueb 1986, *Biology of Amphibians*, The Johns Hopkins Univ. Press, Baltimore, MD U.S.A.). Despite this fact, several birds have been reported to feed on the common lesser toad including the Red-backed Hawk (*Buteo polyosoma*), Burrowing Owl (*Athene cunicularia*), American Kestrel (*Falco sparverius*; Gallardo 1974, *Anfibios de los Alrededores de Buenos Aires*, Editorial Universitaria de Buenos Aires, Argentina) and Cattle Egret (*Bubulcus ibis*; Torres et al. 2000, *Cuad. Herpetol.* 14:81).

Contrary to Gallardo's (1974) field reports, Huertas and Vallejo (1988, *Bol. Soc. Zool. Urug.*, 2° época, 4:46–49), based on laboratory observations, reported that the American Kestrel, which typically kills and eats a variety of non-bufonid anuran species, does not kill and eat the common lesser toad (including small-juvenile toads which have more toxins than adults), perhaps being unable to avoid irritation caused by the secretion of the toad's dorsal glands.

Corn (1993, *Herpetol. Rev.* 24:57) and Brothers (1994, *Herpetol. Rev.* 25:117) reported that the American Crow (*Corvus brachyrhynchos*) and Common Raven (*Corvus corax*) fed on the congeneric, and also toxic, boreal toad (*Bufo boreas*), eviscerating them from the ventral side, as described above. Species that feed successfully on the common lesser toad and other bufonids may be able to do so by making ventral holes in the frog's bodies. This method of consumption may help the predator avoid the noxious substances.

We captured and weighed several common lesser toads in order to assess their potential energetic value to the caracara. The toad's small body size ($\bar{x} = 15.62$ g ± 4.28 g SD, range = 10.26–24.88 g, $N = 9$) along with its toxicity suggests little energetic benefit relative to handling cost, for the caracara (body mass ca. 300 g). However, during the breeding season, when rainfall is high, toads are numerous and are often observed concentrated around ponds (pers.

obs.). This seasonal abundance of the common lesser toad might compensate for what might otherwise be a marginal resource.

We thank G. Finarelli for her assistance with fieldwork and J.L. Morrison and three anonymous reviewers for their comments on earlier versions of the manuscript.—**Leandro Alcalde (e-mail address: alcalde@ilpla.edu.ar) and Sergio D. Rosset, Contribución Científica n° 750 del Instituto de Limnología Platense “Dr. Raúl A. Ringuelet” (ILPLA), CC 712 (1900) La Plata, Argentina.**

Received 15 April 2002; accepted 21 December 2003

Associate Editor: Joan L. Morrison

J. Raptor Res. 38(2):191

© 2004 The Raptor Research Foundation, Inc.

CONSUMPTION OF A RINGED KINGFISHER (*MEGACERYLE TORQUATA*) BY A WHITE-TAILED HAWK (*BUTEO ALBICAUDATUS*) IN SOUTHEASTERN BRAZIL

The White-tailed Hawk (*Buteo albicaudatus*) is a poorly known species ranging from southern Texas to northern Argentinean Patagonia (Farquhar 1992, *The Birds of North America*, No. 30, Washington, DC U.S.A.). Few data are reported on its diet, which comprises insects, rodents, reptiles, and birds (Farquhar 1992, Sick 1993, *Birds in Brazil: a natural history*. Princeton Univ. Press, Princeton, NJ U.S.A.). Virtually no data are published on its ecology in South America.

We observed a feeding event by the White-tailed Hawk in the 2300 ha Itirapina Ecological Station (22°12'S, 47°54'W), State of São Paulo, Brazil. On 23 April 1998, at 1300 H, while driving a car through the savannah grassland, we observed an adult White-tailed Hawk feeding on dead Ringed Kingfisher (*Megaceryle torquata*). The fresh kingfisher remains were in a small tree, ca. 2 m above the ground. As we approached, the hawk flew away and the remains fell to the ground. Only the complete cranium, cervical vertebrae, ulna, metacarpals, phalanges, and some rectrices were left by the hawk when we inspected the carcass. The Ringed Kingfisher is a piscivorous and semiaquatic bird associated with rivers, ponds, lakes, and reservoirs, occurring from extreme southern Texas to southernmost South America (del Hoyo et al. 2001, *Handbook of the birds of the world*. Lynx Edicions, Barcelona, Spain). The nearest aquatic environment, a reservoir, was located ca. 2 km away from the observation site. It is possible, therefore, that the kingfisher could have been passing over the grassland savannah when captured. This may have been the case as the White-tailed Hawk is known to kill and consume prey in or nearby the site of predation (M.A.M. Granzinolli pers. obs.). The Brazilian subspecies, *B. a. albicaudatus*, has a mass ranging from 850–884 g (del Hoyo et al. 1994.) The Ringed Kingfisher body mass ranges from 305–341 g (Sick 1993). Therefore, the kingfisher represented 34.5–40.1% of adult mass of the hawk. Other authors have reported consumption of birds by White-tailed Hawks, but few with a mass of more than 300 g (see Farquhar 1992). However, 43 of 259 pellets from the State of Minas Gerais in southeast Brazil contained birds and, except for one individual with a mass of 72 g, all the others were less than 40 g (M.A.M. Granzinolli and J.C. Motta-Junior unpubl. data). According to the latter study, which evaluated the hawk's diet over a 1-yr period, birds are relatively uncommon prey, totaling 11.1% of consumed biomass of this species. Thus, the present observation suggests that this hawk subspecies can also prey upon larger birds occasionally. Also, we note that White-tailed Hawks are known to scavenge on dead animals (Farquhar 1992) and that the kingfisher carcass we found may not have been captured and killed by the hawk. Nonetheless, we suggest that the feeding event we observed was the result of predation and our record documents the consumption of a relatively large bird in the diet of the White-tailed Hawk.

We thank Fundação de Amparo a Pesquisa do Estado de São Paulo for financial support and Denise Zanchetta from Instituto Florestal de São Paulo for the license to conduct studies in the Ecological Station. C. Farquhar and Adriana A. Bueno made suggestions on the manuscript. This is publication No. 16 of the project “Ecology of the Cerrados of Itirapina.”—**José Carlos Motta-Junior (e-mail address: mottajr@ib.usp.br) and Marco Antonio Monteiro Granzinolli, Departamento de Ecologia, Instituto de Biociências, Universidade de São Paulo, 05508-900, São Paulo, SP, Brazil.**

Received 11 June 2003; accepted 18 December 2003

J Raptor Res. 38(2):192

© 2004 The Raptor Research Foundation, Inc.

GOLDEN EAGLE (*AQUILA CHRYSÆTOS*) PREDATION ATTEMPTS ON MERRIAM'S TURKEYS (*MELEAGRIS GALLOPAVO MERRIAMII*) IN THE SOUTHERN BLACK HILLS, SOUTH DAKOTA

While trapping Merriam's Wild Turkeys (*Meleagris gallopavo merriami*), we witnessed three predation attempts by Golden Eagles (*Aquila chrysaetos*) on turkeys during winter (January–March) and spring–summer (April–July), 2001–03. Merriam's turkeys in the southern Black Hills of South Dakota primarily use (i.e., roost, feed, and loaf) xeric habitats dominated by ponderosa pine (*Pinus ponderosa*). The first observation of an eagle attempting to prey upon turkeys occurred at a bait-site used to capture turkeys. At approximately 0800 H, 5 February 2001, 13 adult male turkeys were at the bait-site feeding while we observed from a ground blind. Four of the turkeys looked up and emitted alarm “putt” vocalizations (Williams 1984, *The voice and vocabulary of the wild turkey*. Real Turkeys, Gainesville, FL U.S.A.). Within 2–3 sec all the birds were alert and very vocal. At this point, we observed a Golden Eagle dive toward the turkeys. The turkeys flew into the trees, seeking shelter in a thick stand of young-ponderosa pine trees. The eagle followed the turkeys, but captured no birds. The turkeys did not return to the bait-site until the following day.

A second attempt occurred while we were collecting habitat data in the afternoon (1400–1500 H) at a ponderosa pine feeding site on 23 January 2002. While walking toward a radio-marked female turkey in a flock containing 35 females and 10 males, we heard the flock emitting fast alarm “putt” vocalizations. Due to the steep terrain and thick cover, we were able to approach to within 40 m of the flock and could see several females above our position in a thick stand of young ponderosa pine. We noticed a Golden Eagle soaring overhead, and as the eagle neared the flock, the turkeys once again began to emit alarm “putt” vocalizations, which increased in intensity as the Golden Eagle approached the flock. When the eagle was within 80 m of the birds, it went into a dive and maneuvered through the young pine stand and into the flock of turkeys. After hitting several turkeys with its talons and body, the Golden Eagle and two turkeys rolled down the slope and stopped several m below the flock. Both the turkeys struck by the eagle regained their balance and ran back into the flock. Soon after, three different turkeys left the flock and ran at the eagle as it stood below. The turkey's aggressive calling, quick movements, and flailing of wings at the eagle startled the eagle and it quickly left and glided off the slope avoiding further confrontation on the ground with the turkeys. Once in flight, the eagle soared twice over the flock at a height of about 10–15 m, never reentering the flock. The turkeys remained in the dense stand of young ponderosa pine as the eagle made two more approaches.

A third predation attempt occurred while we were observing a radio-marked female and her 6-d-old brood along the edge of a meadow on 11 June 2003. We were roughly 70 m from the female and her brood, watching them feed along the edge of a meadow for 4 min when suddenly the female laid flat in the grass. A Golden Eagle immediately flew from the nearby trees, folded its wings, and dove into the grass ca. 5 m from the hiding female. The female then quickly rose from its hiding position and started emitting fast alarm “putt” vocalizations and circling the raptor trying to attract its attention. The Golden Eagle ignored the “putting” female and appeared to be consuming something on the ground beneath it. After 2 or 3 min the eagle became nervous and flew to a nearby perch. We immediately approached the kill site and found two dead poults. One poult had its head and neck eaten, the other poult was not consumed, but a necropsy revealed it had talon puncture wounds on the neck and breast.

Other observations of wild turkey-raptor interactions have been reported. Rio Grande Wild Turkey (*M. g. intermedia*) behavior (i.e., alarm calls and heightened wariness) has been described for birds reacting to the harassment of overhead flying golden eagles (Thomas et al. 1964, *Wilson Bull.* 76:384–385). Poult protection behavior has been observed by Merriam's females toward a goshawk (*Accipiter gentilis*) (Lehman 2003, *Prairie Nat.* 35:47–48) and by Rio Grande females toward a Red-tailed Hawk (*Buteo jamaicensis*) (Butts 1977, *Southwest. Nat.* 22:404–405).

All of our observed predation attempts occurred within a 16-km radius of Pringle, South Dakota in the southern Black Hills. This study was supported by federal aid funds through the South Dakota Department of Game, Fish & Parks, and by the National Wild Turkey Federation. We thank L.D. Flake, M. Kochert, and two anonymous referees for reviewing this manuscript.—**Chad P. Lehman (e-mail address: turkeys@gwtc.net) and Dan J. Thompson, Wildlife and Fisheries Sciences, South Dakota State University, Box 2140B, Brookings, SD 57007 U.S.A.**

Received 30 July 2003; accepted 13 February 2004

J. Raptor Res. 38(2):193–194

© 2004 The Raptor Research Foundation, Inc.

A RECORD OF THE ORNATE HAWK-EAGLE (*SPIZAETUS ORNATUS*) IN NAYARIT, MEXICO

Ornate Hawk-Eagles (*Spizaetus ornatus*) inhabit tropical and subtropical zones, in well-preserved interior forests, from sea level to 1500 m. Habitat associations include tropical rainforests and deciduous forests, cloud forests, and occasionally pine-oak (*Pinus-Quercus*) forests (Iñigo-Elías et al. 1987, *Condor* 89:671–672; Iñigo-Elías 2000, pages 122–124 in G. Ceballos and L. Márquez Valdelamar [Eds.], *Las Aves de México en Peligro de Extinción*. CONABIO-UNAM-Fondo de Cultura Económica, Mexico). However, this species also has been recorded from old second-growth and coffee plantations with native trees providing canopy cover. Ornate Hawk-Eagles have been documented from southern Mexico to Colombia and Ecuador (Iñigo-Elías 2000). In Mexico, they have been recorded on the slope of the Gulf of Mexico, from Tamaulipas and San Luis Potosi to Chiapas and the Yucatan Peninsula (Fig. 1). On the Pacific slope they have been recorded in the state of Colima and Jalisco, with an isolated record from Guerrero (Iñigo-Elías 2000). Ornate Hawk-Eagles have always been considered uncommon to rare, with low reproductive potential, producing one offspring every 2 yr (Iñigo-Elías 2000). Habitat requirements, low productivity, and low abundance make them highly vulnerable to extinction (Ferguson-Lees and Christie 2001, *Raptors of the world*. Houghton Mifflin Company, New York, NY U.S.A.).

During a mammal survey of the southwestern portion of the state of Nayarit, Mexico, we observed and photographed an Ornate Hawk-Eagle on 22 February 2003, at 1300 H soaring at a low altitude not more than 100 m above the canopy, constantly calling. The locality was 105°13'W and 21°41'N, elevation 212 m; southwest of the community named “El Cora,” within the municipality of San Blas, Nayarit. The eagle perched first on a torote tree (*Bursera* sp.) and moved to an unidentified snag 10 min after it was first observed perched; the height of both trees was >20 m. The habitat is a semi-evergreen rainforest, with an abundant source of water from a nearby river. The site is within a single 225-km² patch of semi-evergreen forest (Palacio-Prieto et al. 2000, *Invest. Geogr. Bolet. Instit. Geogr. UNAM* 43: 183–203), apparently protected from development. We estimated the age of the observed individual to be transitional,

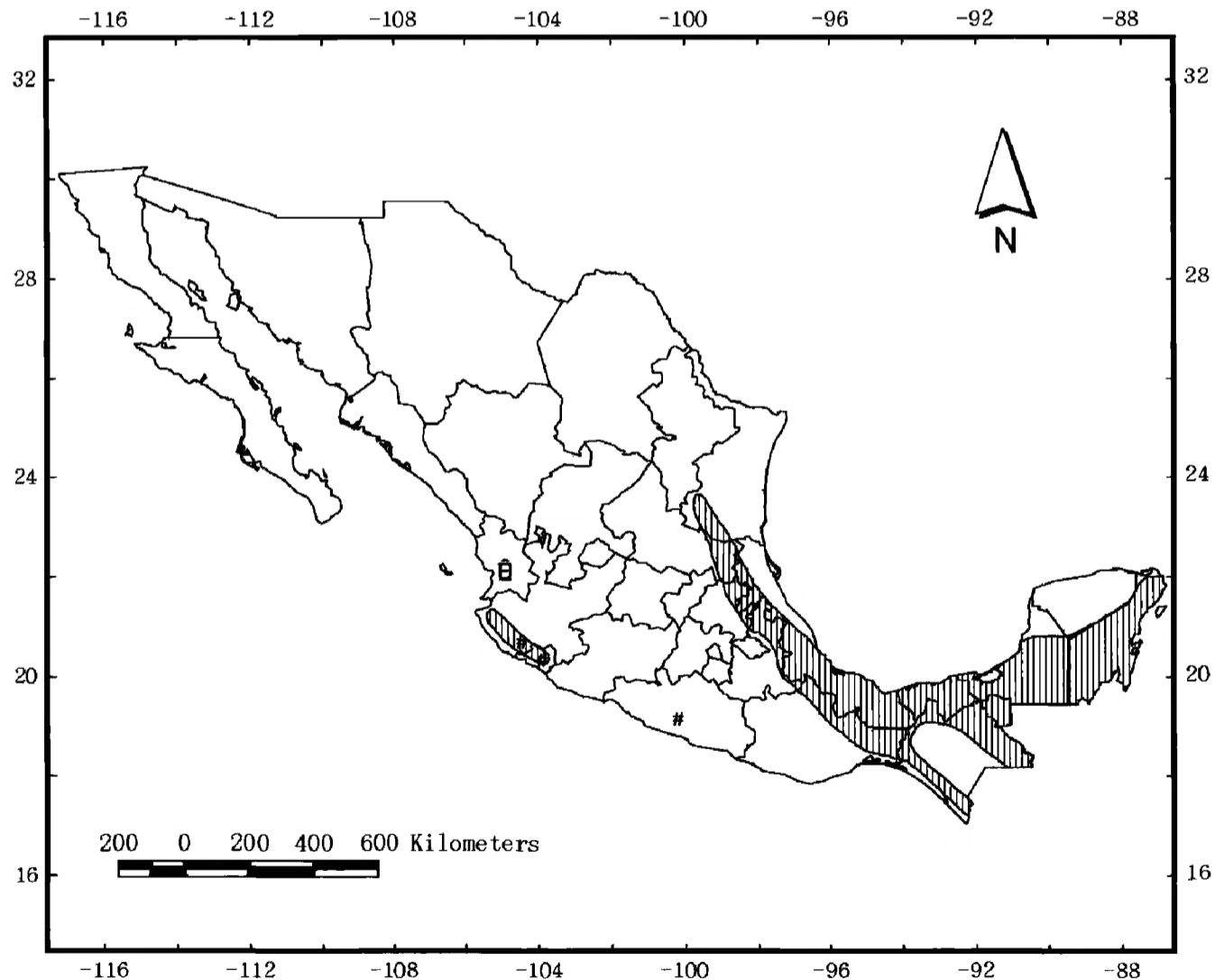


Figure 1. Distribution range for Ornate Hawk-Eagle, modified from Iñigo-Elías (2000) and Howell and Webb (1995). The star shows the Nayarit record, black circles are verified records.

between 2- and 3-yr-old, but not yet a mature adult (González García and Iñigo-Elías pers. comm.). Distinct characters for identification were the plumage, the barred legs, and flight pattern (Iñigo-Elías 2000). The nearest verified records for the Ornate Hawk-Eagle are located in Sierra Autlán, Jalisco (Schaldach 1969, *An. Inst. Biol. UNAM* 40:299–316) and the town of Pueblo Juárez, Colima (Schaldach 1963, *Proc. West. Found. Vertebr. Zool.* 1:1–100), located 200 and 280 km, respectively, from our sighting. Several authors (Iñigo-Elías 2000, Howell and Webb 1995, *A guide to the birds of Mexico and northern Central America*, Oxford Univ. Press, London, U.K.) delineate the Pacific slope range of Ornate Hawk-Eagle into Jalisco, based on one verified record in the southern portion of Jalisco.

At least one hawk-eagle, the Javan Hawk-Eagle (*Spizaetus bartelsi*), apparently shows long-distance dispersal capability between patches of suitable habitat (>37 km; S. van Balen, V. Nijman, and H.H.T. Prins 2000, *Biol. Cons.* 96:297–304). Even if these movements are typical of the genus *Spizaetus*, our record is disjunct from other reported sightings, which probably indicates that the observed hawk-eagle came from the nearest population in Jalisco. Ornate Hawk-Eagle territories may include 13.75 km² in the tropical rainforest of Guyana (Thiollay 1989, *Cons. Biol.* 3:128–137). If our record was a hawk-eagle from the Jalisco population it would have traveled ca. 54 home-range diameters.

This observation increases the known range of the Ornate Hawk-Eagle and emphasizes the lack of biological data for most of the mountain ranges in the western Pacific slope of Mexico. We strongly recommend initiating surveys for Ornate Hawk-Eagles and other raptors in the mountains between our sighting record and the known Jalisco population.

We would like to thank Fernando Gonzalez and Eduardo Iñigo-Elías for corroborating the species identity based on our photograph. We would also like to thank Allen Fish (Golden Gate Raptor Observatory) and Erin Boydston (USGS Golden Gate National Recreational Area) for their comments and help on the literature review. We would also like to thank the reviewers.—**Carlos A. López González (e-mail address: cats4mex@aol.com), Eduardo Ponce Guevara, Karla Pelz Serrano, Hugo Luna Soria, and Rodrigo Sierra Corona, Licenciatura en Biología, Universidad Autónoma de Querétaro, Cerro de las Campanas S/N, Col. Niños Héroes, C. P. 76010, Querétaro, Querétaro, Mexico.**

Received 21 June 2003; accepted 27 January 2004

A Telemetry Receiver Designed with The Researcher in Mind

What you've been waiting for!

Finally, a highly sensitive 999 channel synthesized telemetry receiver that weighs less than 13 ounces, is completely user programmable and offers variable scan rates over all frequencies. For each animal being tracked, the large LCD display provides not only the frequency (to 100Hz) and channel number, but also a 7 character alphanumeric comment field and a digital signal strength meter. Stop carrying receivers that are the size of a lunch box or cost over \$1500. The features and performance of the new R-1000 pocket sized telemetry receiver will impress you, and the price will convince you.

Other Features Include:

- Factory tuned to any 4MHz wide segment in the 148-174MHz Band • Very high sensitivity of -148dBm to -150dBm • Illuminated display and keypad for use in low light or darkness • User selectable scan rates from 1-30 seconds in 1 second steps • Rechargeable batteries operate the receiver for 12 hours and can be replaced with standard AA Alkaline batteries in the field. Both 12vdc and 110vac chargers are included.

- 6.1" (15.5cm) high,
2.6" (6.6cm) wide,
1.5" (3.8cm) deep.

- 3 year warranty
- 1 day delivery

\$695.00

Please specify desired 4MHz
wide segment in the
148-174MHz band

Visit our
website for
complete
specifications,
operating
manual and
information
on the R-1000
or call our
toll-free number
to order your
receiver now.

**Try the
New R-1000
and You'll Be
Impressed!**



COMMUNICATIONS SPECIALISTS, INC.

426 West Taft Avenue • Orange, CA 92865-4296 • 1-714-998-3021 • Fax 1-714-974-3420
Entire U.S.A. (800) 854-0547 • Fax (800) 850-0547 • <http://www.com-spec.com>





Buteo Books

orders:800-722-2460

phone:434-263-4842

fax:434-263-4842

Buteo Books is the largest retailer of Ornithology books in North America, with over 2,000 in-print titles in stock.

A FEW BOOKS ON BIRDS OF PREY AND FALCONRY

Handbook of the Birds of the World. The first seven volumes of this projected sixteen-volume work are available for \$185 each. Volume 2 includes diurnal raptors, Volume 3 includes owls. Volume 8, the first to cover Passerines, due Summer 2003.

A Photographic Guide to North American Raptors. Wheeler & Clark. \$24.95
(New Eastern and Western editions by Wheeler are due September 2003.)

Ecology and Conservation of Owls. Ian Newton. \$95

Birds of Prey: Health and Disease. Third Edition. Cooper. \$96.95

North American Falconry and Hunting Hawks. Beebe & Webster. \$55

RARE AND OUT-OF-PRINT ORNITHOLOGY

Buteo Books has a wide selection of used and out-of-print titles available. Our stock changes daily, so call to check availability of that scarce title you're seeking.

BIRDS OF NORTH AMERICA SERIES

In 1992 the American Ornithologists' Union, in partnership with the Academy of Natural Sciences of Philadelphia, undertook the publication of species accounts for each of the more than 700 species which breed in the United States and Canada. These illustrated reviews provide comprehensive summaries of the current knowledge of each species, with range maps and an extensive list of references.

Buteo Books is pleased to offer these individual species accounts for \$7.50 each. All 716 profiles are listed in taxonomic order on our website (conforming with the Seventh Edition of the A.O.U. Check-list of North American Birds). Singles may be ordered by contacting Buteo Books. Shipping and handling is \$4 for the first profile and \$1 for each additional profile to a maximum of \$10 per order.

Visit our website for more information: www.buteobooks.com

allen@buteobooks.com

3130 Laurel Road; Shipman, VA 22971; USA

2004 ANNUAL MEETING

The Raptor Research Foundation, Inc. 2004 annual meeting will be held on 9–13 November 2004 in Bakersfield, California. For information about the meeting see the following website: http://www.calhawkingclub.org/field_meet/34th_annual/ or contact Rick Holderman (parabuteol@cox.net).

Persons interested in predatory birds are invited to join The Raptor Research Foundation, Inc. (see: <http://biology.boisestate.edu/raptor/>). Send requests for information concerning membership, subscriptions, special publications, or change of address to OSNA, P.O. Box 1897, Lawrence, KS 66044-8897, U.S.A.

The Journal of Raptor Research (ISSN 0892-1016) is published quarterly and available to individuals for \$33.00 per year and to libraries and institutions for \$50.00 per year from The Raptor Research Foundation, Inc., 14377 117th Street South, Hastings, Minnesota 55033, U.S.A. (Add \$3 for destinations outside of the continental United States.) Periodicals postage paid at Hastings, Minnesota, and additional mailing offices. POSTMASTER: Send address changes to *The Journal of Raptor Research*, OSNA, P.O. Box 1897, Lawrence, KS 66044-8897, U.S.A.

Printed by Allen Press, Inc., Lawrence, Kansas, U.S.A.

Copyright 2004 by The Raptor Research Foundation, Inc. Printed in U.S.A.

Ⓢ This paper meets the requirements of ANSI/NISO Z39.48-1992 (Permanence of Paper).

RAPTOR RESEARCH FOUNDATION, INC.

Grants and Awards

For details and additional information visit: <http://biology.boisestate.edu/raptor/rrfi.htm>

Awards for Recognition of Significant Contributions.

The **Tom Cade Award** is a non-monetary award that recognizes an individual who has made significant advances in the area of captive propagation and reintroduction of raptors. The **Fran and Frederick Hamerstrom Award** is a non-monetary award that recognizes an individual who has contributed significantly to the understanding of raptor ecology and natural history. Submit nominations for either award to: Dr. Clint Boal, Texas Cooperative Fish and Wildlife Research Unit, BRD/USGS, Texas Tech University, 15th Street & Boston, Ag Science Bldg., Room 218, Lubbock TX 79409-2120 U.S.A.; phone: 806-742-2851; e-mail: cboal@ttu.edu

Awards for Student Recognition and Travel Assistance.

The **James R. Koplín Travel Award** is given to a student who is the senior author and presenter of a paper or poster to be presented at the RRF meeting for which travel funds are requested. Application deadline: due date for meeting abstract. Contact: Dr. Patricia A. Hall, 5937 E. Abbey Rd., Flagstaff, AZ 86004; phone: 520-526-6222 U.S.A.; e-mail: pah@spruce.for.nau.edu

The **William C. Anderson Memorial Award** is given to both the best student oral and poster presentation at the annual RRF meeting. The paper cannot be part of an organized symposium to be considered. Application deadline: due date for meeting abstract, no special application is needed. Contact: Rick Gerhardt, Sage Science, 319 SE Woodside Ct., Madras, OR 97741 U.S.A.; phone: 541-475-4330; email: rgerhardt@madras.net

Grants.

Application deadline for all grants is February 15 of each year; selections will be made by April 15.

The **Dean Amadon Grant** for up to \$1000 is designed to assist persons working in the area of systematics (taxonomy) and distribution of raptors. The **Stephen R Tully Memorial Grant** for up to \$500 is given to support research and conservation of raptors, especially to students and amateurs with limited access to alternative funding. Agency proposals are not accepted. Contact for both grants: Dr. Carole Griffiths, 251 Martling Ave., Tarrytown, NY 10591 U.S.A.; phone: 914-631-2911; e-mail: cgriff@liu.edu

The **Leslie Brown Memorial Grant** for up to \$1400 is given to support research and/or the dissemination of information on African raptors. Contact: Dr. Jeffrey L. Lincer, 9251 Golondrina Drive, La Mesa, CA 91941, U.S.A.; e-mail: JeffLincer@tns.net